 TID-3092

NUCLEAR EXPLOSION EFFECTS ON STRUCTURES AND PROTECTIVE CONSTRUCTION

A Selected Bibliography

Compiled by
John H. Mitchell

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Oak Ridge, Tennessee

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ABSTRACT

References on the effects of nuclear explosions on military, industrial, commercial, residential, and shelter structures are presented in this survey. Also included are abstracts to literature on design of protective structures such as bomb shelters, military installations, and buildings. A total of 240 selected references with author, report number availability, and subject indexes are given.

INTRODUCTION

This bibliography covers the unclassified literature on the design of protective structures and the effects of nuclear detonations on structures. Literature is also given including effects on structure in Hiroshima and Nagasaki. Blast and thermal radiation effects on shelters and structures as well as radiation protection afforded by these structures are included. No attempt has been made to include literature on reactor construction, radiation laboratories, marine vessels, aircraft, and space vehicles. It is hoped that this document will be a useful tool to industrial and military engineers and those interested in civil defense. Report references are arranged alpha-numerically by report number under the name of the issuing agency. The published references are divided into subsections comprised of journal articles, Congressional hearings, translations, and books.

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UNITED STATES
New York, United Nations Headquarters
Washington, D. C., Inter-American Nuclear Energy Commission

REFERENCES

Air Force. Directorate of Intelligence, Washington, D. C.

1
METHODS OF ANALYSIS FOR STRUCTURES SUBJECTED TO DYNAMIC LOADING. Nathan M. Newmark. Dec. 18, 1959. 101p. Decl. Oct. 1, 1951. (Np-3572)

Methods are discussed which may be used for the analysis of structures subjected to impulsive loads resulting from the blast pressures from a large quantity of explosives. Only the general principles and methods are considered. Detailed dimensions of particular structures and specific pressure-time relationships are not described since it is the intention of this discussion to present a general procedure capable of application to many different conditions. The special aim is to consider methods which are applicable to structures which are stressed to the point of failure and therefore which are loaded considerably beyond their range of elastic behavior.

American Gas Association, Inc., New York, New York

2
EFFECTS OF A NUCLEAR EXPLOSION ON TYPICAL NATURAL AND MANUFACTURED GAS UNDERGROUND AND ABOVE-GROUND INSTALLATIONS, INCLUDING APPLIANCES IN HOUSES. Guy Corfield. (In cooperation with the Office of Civil and Defense Mobilization, Washington, D. C.) PROJECT 35.4b [OF] OPERATION TEAPOT–PRELIMINARY REPORT. May 1955. 62p. (ITR-1176)

Typical Natural and Manufactured Gas Industry piping, underground and above-ground equipment, and appliances in buildings, were installed in accordance with current industry practice at various distances from the base of a 500-ft tower at the top of which a 30 KT nuclear device was exploded. The distances were selected and the installations duplicated to produce varying degrees of damage. Underground installations were practically undamaged with the exception that ventilator pipes from a vault at 1,470′ were sheared off at ground level. Service piping, regulators and meters to buildings, and house piping in buildings were undamaged. Appliances in buildings were practically undamaged, and operative, with exception of those in two houses which were either badly damaged or inaccessible due to collapse of houses.

American Machine and Foundry Company, Chicago, Illinois

3
TRANSIENT DRAG AND ITS EFFECT ON STRUCTURES. VOL. II. BIBLIOGRAPHY TO FINAL REPORT. M. Lorraine Liggins. Feb. 24, 1955. 73p. (AD-59870; MR-1013)

A bibliography on drag forces on blunt obstacles is presented for use in blast loading studies. Some references dealing with structural problems and general fluid flow studies are included.

4
FIELD TEST OF REINFORCED-CONCRETE DOME SHELTERS AND PROTOTYPE DOOR. G. L. Neidhardt, R. S. Koike, T. G. Morrison, and W. Tuggle. PROJECT 30.1 [OF] OPERATION PLUMBBOB–PRELIMINARY REPORT. July 1957. 62p. (ITR-1448)

Field tests were made on three 50-ft-diameter reinforced-concrete domes and one 7-ft by 10-ft drawbridge type door. The domes were placed at the 20-, 35-, and 70-psi regions. The preliminary record placed the actual pressures developed in these regions at levels slightly higher than this. The dome in the high-pressure region was nearly destroyed. The windward side of the dome in the medium-pressure region was demolished. The dome in the low-pressure region was not damaged. None of the foundations were damaged. Standing beside the destroyed dome in the 70-psi region was another dome from a separate test. This dome was designed using the same theory as the 30.1 dome but to a thickness sufficient to resist 70-psi with a safety factor. This dome survived the blast with only one perceptible crack. The results support the prediction that initial failure of a dome is limited to a small area; either there is substantial damage or practically no damage at all. The door survived without significant deformation. The only damage was of a minor nature around the edge of the door, and this can be remedied by a slight change in design. The operation mechanism functioned perfectly after the test.

Ammann and Whitney, New York, New York

5
RESPONSE OF DUAL-PURPOSE REINFORCED-CONCRETE MASS SHELTER. E. Cohen and E. Laing. PROJECT 30.2

[OF] OPERATION PLUMBBOB – PRELIMINARY REPORT. Nov. 8, 1957. 58p. (ITR-1449)

This project was conducted to test a reinforced-concrete dual-purpose underground parking garage and personnel shelter designed for a long-duration incident pressure of 30 psi. The estimated peak incident pressure at the structure was 42 psi. To facilitate postshot analyses, soil borings were made to obtain undisturbed samples for determining soil characteristics. Preshot and postshot field surveys were made to determine the total lateral and vertical displacement of the structure. Blast instrumentation consisted of Wiancko pressure gauges, Carlson earth-pressure gauges, dynamic-pressure gauges, and a self-recording pressure gauge. Structural response was recorded by Ballistics Research Laboratory gauges. Radiation measurements were taken using film dosimeters, gamma-radiation chemical dosimeters, and one gamma-rate telemetering unit.

6

RESPONSE OF PROTECTIVE VAULTS TO BLAST LOADING. E. Cohen and E. Laing. PROJECT 30.4 [OF] OPERATION PLUMBBOB – PRELIMINARY REPORT. Sept. 1957. 40p. (ITR-1451)

This project was conducted to test a reinforced-concrete steel-plate-lined vault and steel vault door. The structure was exposed to a nuclear detonation at the predicted 75-psi peak incident pressure level. The recorded peak incident pressure at the structure was approximately 95 psi. To aid postshot analyses, soil borings were made to obtain undisturbed samples for determining soil characteristics. Preshot and postshot field surveys were made to determine the total lateral and vertical displacement of the structure. Blast instrumentation consisted of Wiancko shock pressure gauges and a dynamic-pressure gauge. Structural response was not recorded. Thermal instrumentation consisted of a thermocouple on the front face of the vault, two peak-temperature gauges, and a spring-wound stylus 24-hr temperature recorded on the interior of the vault. Radiation measurements were made using film dosimeters and gamma-radiation differential chemical dosimeters.

Argonne National Laboratory, Lemont, Illinois

7

BIBLIOGRAPHY ON VARIOUS TOPICS PERTAINING TO BLAST EFFECTS. J. C. Heap. Oct. 1957. 23p. (ANL-5792)

The references of this résumé have been obtained largely from a card index compiled at Argonne National Lab. The source of information has been arranged in chronological order according to subject matter, then document number.

Armed Services Technical Information Agency, Arlington, Virginia

8

PROTECTIVE CONSTRUCTION. A ASTIA REPORT BIBLIOGRAPHY. Nov. 1960. 86p. (AD-242653)

This bibliography contains 392 references to unclassified reports related to construction or hardening of strategic military facilities to resist either nuclear or conventional explosives. Literature coverage was restricted to documents within the ASTIA collection, cataloged from 1952 to September 15, 1960. Entries include references to reports pertaining to characteristics of nuclear explosions, propagation of shock waves, underground explosions, soil mechanics, and response of structures to blast.

Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia

9

RESPONSE OF AN ELASTO-PLASTIC SINGLE DEGREE OF FREEDOM SYSTEM TO AN EXPONENTIALLY DECAYING BLAST WAVE. James W. Maloney. June 23, 1959. 65p. (ERDL-1581-TR)

The complete spectrum of results of an elasto-plastic single degree of freedom system subjected to the classical exponentially decaying blast wave is presented in dimensionless form. The equivalent triangle pulses to give the same maximum displacement and time of maximum response of the rigid plastic system are presented as appendices to the report.

Associated Nucleonics, Incorporated, Garden City, Long Island, New York

10

DOSE ATTENUATION BY SOILS AND CONCRETE FOR BROAD, PARALLEL-BEAM NEUTRON SOURCES. David Spielberg and Arthur Duneer. May 1, 1958. 166p. (AN-108)

The theory and results of certain neutron shielding studies performed to supply information primarily for underground bomb shelter design are presented. Specifically, for neutron source energies of 0.025 ev, 0.5 Mev, 7.5 Mev, 10 Mev, and 14 Mev, and various angles of incidence upon the ground, results are presented that show the total neutron plus secondary gamma dose rates which would be received by individuals located in shelters at various distances below ground. To cover the entire range of possibilities, four basically different soil types were analyzed with water contents ranging form zero to saturation. This range also includes concrete. Also, dose rates were calculated for depths ranging from 30 to 1,000 grams/cm^2.

Atomic Energy Commission, Washington, D. C.

11

THE STATEMENT OF DR. W. F. LIBBY BEFORE SPECIAL SUBCOMMITTEE ON RADIATION, JOINT COMMITTEE ON ATOMIC ENERGY PUBLIC HEARINGS ON THE BIOLOGICAL AND ENVIRONMENTAL EFFECTS OF NUCLEAR WAR. June 18, 1959. 18p. (TID-5560)

The effects of radiological warfare on populations are reviewed. It is pointed out that for radiological defense to succeed, it is necessary for people to learn about fall-out and about the effects of nuclear radiation on people, animals, plants, food, and water. In the event of radiological warfare, survival and recovery actions will depend on public knowledge. People must be taught what to do to keep from being killed or injured during radiological warfare. It is the responsibility of the government to encourage technological developments which will improve the effectiveness of defense preparations. A fall-out shelter is essential for a high degree of protection for each family. The shielding afforded by conventional residences is discussed. The design and construction of family and group shelters are described. The need for radiological warning systems is discussed, and two warning systems for individual or family use are described.

Australia. Aeronautical Research Laboratories, Melbourne, Victoria

12
BIBLIOGRAPHY ON THE FATIGUE OF MATERIALS, COMPONENTS AND STRUCTURES. Volume I. 1843-1938. J. Y. Mann, comp. Aug. 1954. 289p. (AD-82763)

A literature search, containing 2119 references, was prepared on the fatigue of materials, components and structures for the assistance of scholars, engineers, designers and research workers. References are included to published information on the subject of fatigue up to the year 1938.

12a
LIST OF REPORTS ON THE FATIGUE OF MATERIALS, COMPONENTS AND STRUCTURES. Structures and Materials Technical Memorandum 82. J. Y. Mann. May 1959. 8p. (SM-82)

A literature search, containing 61 references, is presented on the fatigue of materials, components and structures. References are included to published information on the subject of fatigue up to the year 1959.

Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland

13
SHOCK TUBE TESTS OF MODEL COMMUNAL SHELTERS. William J. Taylor. January 1954. 20p. (BRL-857; AFSWP-725)

Shock tube tests on a $\frac{1}{24}$ scale model air raid shelter are described giving the pressure-time history of several areas in the seating chamber as the shelter model is subjected to a long duration shock wave. Some minor changes in the construction of the shelter entrance-way are suggested which effect significant reduction in pressures in the seating chamber.

14
AIR BLAST LOADING ON A SCALED THREE-DIMENSIONAL STRUCTURE. Charles N. Kingery and John H. Keefer. July, 1955. Decl. Aug. 8, 1957. 74p. (BRL-952; AFSWP-813)

The objectives of this report are to present pressure-time curves from various positions on the front, top and back face of a three-dimensional model and from the curves presented develop a method for predicting air blast loading on full-sized structures exposed to nuclear explosions. The pressure-time curves presented are direct tracings of the records produced by the gages. A method for scaling these curves to any sized structure of the same H : W: L ratio is given. Pressure-time loading on an Upshot-Knothole structure is compared with an adjusted curve from the same position on a $\frac{1}{36}$ scaled model exposed in the shock tube and the result is very promising.

15
AIR BLAST LOADING ON A THREE DIMENSIONAL MODEL OF A GABLED SHELTER. Robert J. Janus and Charles N. Kingery. Jan. 1958. 158p. (BRL-1042)

The air-blast loading on a three-dimensional model of a gabled shelter has been investigated in a shock tube in order to provide data which could be used to formulate design criteria for a blast-resistant structure. The loading was divided into two phases. Diffraction loading was recorded by means of piezo-electric gages located at various points on the surface of the model. The pressure-time records resulting from this instrumentation were supplemented by pressure distribution studies made by the interferometer method (two-dimensional). Drag loading was studied with a transient balance. The data obtained by the different methods were correlated and good agreement was found. The methods of applying shock tube data to field conditions are presented. With these methods, the piezo-gage pressure-time records are compared to records obtained in the field and show a good agreement.

16
LAWS FOR LARGE ELASTIC RESPONSE AND PERMANENT DEFORMATION OF MODEL STRUCTURES SUBJECTED TO BLAST LOADING. W. E. Baker, W. O. Ewing, Jr., and J. W. Hanna. Dec. 1958. 55p. (BRL-1060)

A model law is developed for scaling of response to blast loading of structures which undergo large elastic and plastic deformations. In the derivation of the model law, strain-rate and gravity effects are assumed negligible. The geometrical scaling of response predicted by the law is verified by a series of experiments on small cantilever beams.

17
SHOCK TUBE TESTS OF GLAZING MATERIALS. William J. Taylor and Robert O. Clark. Nov. 1952. 37p. (BRL-Memo-626)

In the event of an atomic bomb attack, the hazard of flying glass may extend over an area of approximately 200 square miles. This investigation provides evidence that the area of common window glazing hazard could be reduced to coincide with the area of moderate structural damage or to approximately 7 square miles, by proper selection of glazing material.

18
AIR BLAST LOADING ON THREE-DIMENSIONAL SCALE MODELS OF DOME SHAPE. Elbridge Rines, Mead Ferguson, and Charles Kingery. April 1955. 142p. (BRL-Memo-889; AFSWP-773)

More than one hundred curves are presented for air blast loading on scale models of a dome shape structure of Operation Greenhouse. Explanation of the curves has been given so that they may be used for comparison with the results of full scale tests and of other experiments in shock tubes.

19
AIR BLAST LOADING ON THREE-DIMENSIONAL SCALE MODELS OF A SEMI-CYLINDER. F. B. Smith, Jr., E. G. Rines and J. H. Keefer. July 1957. 77p. (BRL-Memo-1092; AFSWP-1047)

An investigation was made to record the diffraction loading on a scaled steel model (semi-cylinder) exposed in a shock tube. The model used was a $\frac{1}{72}$ scale of a Navy Structure exposed at Operation Greenhouse. Pressure vs. time curves of the diffraction phase of the air blast loading at 28 positions, 3 orientations on 3 shock strengths are presented. The curves are presented so that comparisons may be made with results of full scale tests and other shock tube experiments.

20
SHIELDING EFFECT OF WALLS. April 1952. 19p. (BRL-TN-582)
A series of spark shadowgraphs made in a small shock tube are presented which show the configuration of shock front diffraction patterns set up by two model walls placed so that the first wall essentially shields the second. The relative heights of the two walls are varied as well as the distance between them. These shadowgraphs were made to serve as an aid in interpretation of records to be obtained by the Blast Model Studies Section, Sandia Corporation, on a series of large scale diffraction experiments.

21
DEVICES FOR REDUCING BLAST EFFECTS IN VENTILATING SYSTEMS. William J. Taylor, Wesley E. Curtis, and Robert O. Clark. Feb. 1954. Decl. Aug. 8, 1957. 36p. (BRL-TN-869; AFSWP-730)
Results of shock tube tests on ten model ventilator designs are reported showing their relative effectiveness in reducing the passage of air shocks. A muffler type ventilator is described which is the most efficient of the design tested in preventing the passage of air shocks into ventilating systems and reducing the high velocity air flows.

22
INSTRUMENTATION OF STRUCTURES FOR AIR-BLAST AND GROUND-SHOCK EFFECTS. J. J. Meszaros, H. S. Burden and J. D. Day. PROJECT 3.7 [OF] OPERATION PLUMBBOB–INTERIM TEST REPORT. Dec. 6, 1957. 62p. (ITR-1426)
A basic description of the instrumentation employed by the Ballistic Research Laboratories during Plumbbob for obtaining air-blast and ground-shock loading and response of structures for Projects 3.1, 3.2, 3.3, 3.6, 30.1, 30.2, 30.3, 31.4 and 31.5 is given in this report. Self-recording gages for measuring peak pressures, pressures versus time, dynamic pressures versus time, and displacement versus time are described; electronic gages for obtaining time-dependent records of pressure, dynamic pressure, acceleration, displacement, and earth pressure are described. For each type of gage, details are given on the recording mechanism, transducer element, gage mount, calibration, and data presentation. Also, a plot of the field layout is shown. A tabulation indicating the general success of the instrumentation recording operations and a discussion of anomalies is presented. Finally, recommendations for more-effective instrumentation practices are listed.

Broadview Research Corporation, Burlingame, California

23
BLAST SHIELDING IN COMPLEXES. A. B. Willoughby, K. Kaplan, and N. R. Wallace. Aug. 1958. 158p. (AFSWC-TR-57-29; AD-144535)
Results are presented of an experimental investigation of the shielding effects of city complexes on the blast loading of structures both within the complex and in the region surrounding the complex. The approach used was to expose small scale models of idealized complexes of city buildings to small high explosive charges (simulating about 140 KT weapons) and to measure building loading and shock wave characteristics at various points in and around the models. For the test conditions investigated, it was found that the shielding effects of the city complex on the shock waves were limited to the complex itself, and its immediate environs. At relatively small distances behind the complex the shock waves exhibited virtually complete recovery. Within the complex, however, significant changes in loadings were found to take place when the spacing between structures was comparable to or less than the structure height.

Brookhaven National Laboratory, Upton, New York

24
FALLOUT STUDIES AT BNL DURING THE SUMMER OF 1956. J. Weiss and F. P. Cowan. 22p. (BNL-436)
Results are reported from a study of the characteristics of surfaces in regard to fall-out contamination and decontamination. The surfaces of interest were those used commonly for buildings, roads, and sidewalks. Panels of building materials were exposed during the Pacific weapons tests in the summer of 1956. The panels were surveyed after each period of rain. If there was no rain, the panels were surveyed three times a week. Samples of rainwater were also collected for analysis. The samples were processed, using standard analytical procedures, and were analyzed for total activity and levels of molybdenum-99, iodine-131, zirconium-95, and strontium-90. The effects of bath with clear water or detergent were measured. Data are presented graphically, and results are discussed. Activity of the specific isotopes followed no regular pattern, either on a concentration basis or a total activity basis. It was concluded that when the volume of rain is small, the concentration of gross activity is high, and when the volume is large, the concentration is low. The amount of activity which comes down in rain is roughly proportional to the amount of rain that falls.

25
THE ACCUMULATION OF RADIOACTIVE FALLOUT ON TYPICAL MATERIALS OF CONSTRUCTION. F. P. Cowan. Mar. 1958. 10p. (BNL-497)
Test panels of six materials commonly used in building construction were exposed to the weather continuously and were counted at intervals before and after attempts at decontamination with water or household detergents. The exposures were made at Upton, New York, during the 1957 Nevada test series. Data are tabulated and presented graphically.

Bureau of Yards and Docks, Washington, D. C.

26
STUDIES IN ATOMIC DEFENSE ENGINEERING. Arthur B. Chilton, A. F. Dill, J. G. Hammer, H. L. Murphy, Erwin E. Shalowitz, and L. N. Saunders, Jr. Jan. 1957. 91p. (NAVDOCKS-P-290)
The information compiled forms an introduction to those phases of defense engineering which are of particular interest to engineers concerned with planning, building, and

maintaining military installations. Discussions are included on the following: failure criteria as applied to defense engineering, blast damage to houses and utilities, an evaluation of incendiary effects on naval shore installations, an evaluation of radioactive fall-out hazards, biological effects, the improvement of conventional designs to resist blast loadings, the dynamic behavior of simple structures, structural response to blast, the behavior of reinforced concrete beams under dynamic blast loading, the strength of materials under dynamic loadings, the resistance of glass windows to nuclear blast, personnel protective shelters, emergency shelters for protection, concrete as a gamma radiation shield, the shielding of gamma rays obliquely incident upon concrete walls, decontamination principles and techniques in radiological recovery, and the graphical solution of target analysis probability problems.

27

DESIGN OF PROTECTIVE STRUCTURES (A NEW CONCEPT OF STRUCTURAL BEHAVIOR). Arsham Amirikian. Aug. 1950. 76p. (NP-3726; NAVDOCKS-P-51)

Experimental data are reported on the blast effects from conventional weapons on different type of structures. The second half of the report discusses the effect of nuclear blast on these same type of structures. An analysis based on a new concept of structural resistance for the design of structure to resist nuclear blast is given. This analysis should aid the structural engineer in designing military and civilian protective structures.

28

REPORT OF THE BEREAU OF YARDS AND DOCKS MISSION TO JAPAN 1945. VOL. 1 of 7. PART I. GENERAL REPORT AND PART II. TABULATION OF DAMAGE IN HIROSHIMA AND NAGASAKI. June 1946. 111p. Part I. Decl. April 1, 1960. Part II Decl. Feb. 2, 1953. (NP-3917)

Surveys were made of the damage wrought by the nuclear bombs and other weapons on targets in Japan. Information is included on the following: types of nuclear detonations and other explosive devices; a comparison of the effectiveness of the weapons; defense of existing naval facilities; characteristics of the nuclear weapons; analysis of typical damage from nuclear bombs; principles and procedure design of structures; suggested research on nuclear explosion effects; future types of nuclear devices; safe distances from nuclear detonations for buildings of different construction. Data on damage at Hiroshima are tabulated for reinforced-concrete, steel, masonry, timber, structural-steel and reinforced-concrete, and miscellaneous structures. Nagasaki tabulations include reinforced-concrete, structural-steel, masonry, and miscellaneous structures.

29

REPORT OF THE BUREAU OF YARDS AND DOCKS MISSION TO JAPAN 1945. Volume 2. Part III. INCIDENTS IN HIROSHIMA. Section 1. 169p. Decl. Feb. 2, 1953. (NP-3975)

Descriptions are given of Hiroshima structures that were inspected by members of the Physical Damage Section of the United States Strategic Bombing Survey. Information is presented on structural damage and distance from ground zero is given for each structure. Photographs of damaged areas and structures are also included. The following types of structures are discussed; reinforced-concrete buildings; brick structures; a brick stack; hothouses, steel frames with trusses and glass ponds, a concrete block building; concrete-frame buildings; a brick masonry building; a granite- and brick-masonry building; and a steel-frame building. (See also Section 2, Part III, Vol. 3.)

30

REPORT OF THE BUREAU OF YARDS AND DOCKS MISSION IN JAPAN 1945. Vol. 3. Part III. INCIDENTS IN HIROSHIMA. Section 2. 173p. Decl. Feb. 2, 1953. (NP-3918)

Descriptions are given of Hiroshima structures that were inspected by members of the Physical Damage Section of the United States Strategic Bombing Survey. Information is presented on structural damage and distance from ground zero is given for each structure. Photographs of damaged areas and structures are also included. The following types of structures are discussed: reinforced-concrete buildings; reinforced-concrete frame buildings; concrete-frame buildings; concrete buildings; steel-frame buildings; steel buildings; wood-frame buildings; wood buildings; masonry buildings; brick buildings; steel tanks; brick and wood buildings; brick and concrete buildings; storage tanks; granite structures; reinforced-concrete stacks; concrete stacks; brick stacks; steel stacks; railroad bridges; reinforced-concrete bridges; concrete bridges; a predestrian suspension bridge; and steel bridges. (See also Section 1, Part III, Vol. 2.)

31

REPORT OF THE BUREAU OF YARDS AND DOCKS MISSION TO JAPAN 1945. Vol. 4. Part IV. INCIDENTS IN NAGASAKI. 192p. Decl. Feb. 2, 1953. (NP-3916)

Descriptions are given of Nagasaki structures that were inspected by members of the Physical Damage Section of the United States Strategic Bombing Survey. Information is presented on structural damage and distance from ground zero is given for each structure. Photographs of damaged areas and structures are also included. The following types of structures are discussed: steel mill-type structures; steel-frame structures; reinforced-concrete frame buildings; reinforced-concrete buildings; concrete buildings; steel structures; steel tanks; a masonry building; wood buildings; reinforced-concrete bridges; concrete bridges; railroad bridges; steel bridges; reinforced-concrete stacks; a concrete fence; a reinforced-concrete retaining wall; a concrete wall; a brick wall; concrete posts; steel towers; and an underground reinforced-concrete vault.

32

REPORT OF THE BUREAU OF YARDS AND DOCKS MISSION TO JAPAN 1945. Vol. 5. Part V. DAMAGE FROM HIGH-EXPLOSIVE AND INCENDIARY BOMBS AT KURE AND OTHER TARGETS. Decl. Feb. 2, 1953. 131p. (NP-3974)

A survey of damage from high-explosive and incendiary bombs at Kure and other targets in Japan is reported. Descriptions are given of the structures and photographs of damaged areas and structures are included. The following types of structures are discussed: wood buildings; wood and steel buildings; reinforced-concrete buildings; brick steel-frame buildings; corrugated-iron wood-frame buildings; corrugated-iron steel-frame buildings; brick buildings; and brick wood-frame buildings.

33

REPORT OF THE BUREAU OF YARDS AND DOCKS MISSION TO JAPAN 1945. Vol. 6. Part VI. DYNAMICS OF STRUCTURES UNDER ATOMIC BOMBING. H. M. Westergaard and Stanley Rockefeller. Decl. Feb. 2, 1953. 108p. (NP-3920)

Blast loads are discussed, not in terms of qualities of any particular nuclear explosion, nor in terms of distances from the explosion, but in terms of the peak air pressure that would occur at the site of the structure if the structure has been removed in advance. The loads, including the effects of reflections of the wave, are expressed in terms of the peak pressures. The theory of dynamics of structures that are set in motion by the transient loads of shock and wind is discussed. Some comments on the dynamics of structures in Hiroshima and Nagasaki are included.

34
REPORT OF THE BUREAU OF YARDS AND DOCKS MISSION TO JAPAN 1945. Vol. 7. Part VII. Section 1. THEORY OF DYNAMIC RESISTANCE AND DESIGN OF STRUCTURES SUBJECTED TO ATOMIC BOMBS. Henri Marcus. Decl. Feb. 2, 1953. 188p. (NP-3919(Sec.1))

A study was made in order to determine the stresses and strains by the nuclear explosions in various structures in Hiroshima and Nagasaki and in this way to evaluate the resistance of structures to the tremendous impact caused by the nuclear detonations. Information is included on the following: the effect of various types of dynamic loads and the dynamic characteristics of a structure. (See also Vol. VII, Section 2.)

35
REPORT OF THE BUREAU OF YARDS AND DOCKS MISSION TO JAPAN 1945. Vol. 7. Part VII. Section 2. THEORY OF DYNAMIC RESISTANCE AND DESIGN OF STRUCTURES SUBJECTED TO ATOMIC BOMBS. Henri Marcus. Decl. Feb. 2, 1953. 201p. (NP-3919(Sec.2))

This section of Volume VII is a continuation of the report on a study to determine the stresses and strains by the nuclear explosions in various structures in Hiroshima and Nagasaki. This study was made in order to evaluate the resistance of structures to the tremendous impact caused by the nuclear detonations. Information is included on the following: the effect of various types of dynamic loads; a study of impact tests on reinforced concrete beams; an analysis of the stresses produced by the nuclear explosions in structural elements of Japanese buildings; recommendations for the design of bomb resistant structures; typcial damage caused by nuclear bombs on Japanese structures; and the necessity and scope of further research on the resistance of structures to the blast. (See also Vol. VII, Section 1.)

University of California. Institute of Engineering Research, Berkeley, California

36
PROGRESS REPORT ON THE SAMPLE SURVEY OF SHELTER AREAS. D. W. Barker and D. J. Sundblom. Feb. 2, 1959. 40p. (NP-8132)

A pilot study was made of shelter areas in a census tract in Richmond, California. Residential structures in the tract were enumerated and a sample of 300 structures was selected at random and individually photographed. Data obtained on each house included a rough sketch of the exterior wall plan, a simple description of the building materials used, the shape of the roof, the presence of fireplaces and basements, total floor area, and age of building. A statistical study was made of the suitability of the structures as fall-out shelters. Appended is a discussion of the statistical problem in detail.

University of California. Atomic Energy Project, Los Angeles, California

37
BEHAVIOUR OF SHOCK WAVES ENTERING MODEL BOMB SHELTERS. B. B. Dunne and Benedict Cassen. April 25, 1955. 19p. (UCLA-332)

The use of a spark shadowgraph with effective exposure time of a fraction of a microsecond has enabled very sharp pictures to be obtained of the time sequence of shock wave advance, reflection, diffraction, and turbulent breakup in models placed in a 4×4 inch square cross section shock tube. The equipment has been used to gain considerable information on the penetration of shock waves into model shelters. Although it is expected that inertial forces would scale accurately in small models, it is evident from the results that viscous forces play an important part in kinetic energy dissipation, and these forces would not be expected to scale accurately. However, the production and behavior of strong vortices in the models indicate that they should be considered as a full-scale factor in effects on personnel.

Canada. Defence Research Chemical Laboratories, Ottawa

38
PROTECTION FACTORS FOR HOUSES USING RADIOACTIVE SOURCES. J. R. Cunningham, R. Wilson, F. A. Bury, and J. K. M. Flexman. Nov. 1957. 20p. (DRCL-260)

The shielding afforded by two types of dwellings to the gamma rays from a simulated infinite contaminated field has been studied. Both the basements and the ground floors of the houses were examined using both Co^{60} and Cs^{137} as contaminants. A method was devised whereby single sources were used. The sources were moved at a constant rate along lines parallel to the walls of the house and the dose rates recorded as a function of the position of the source along these lines. The area under these curves gave the dose rates from simulated line sources. The dose rates from these source lines were plotted against the distance from the house, the area under this curve giving the dose rate from a uniformly contaminated area surrounding the house. A similar method was used for determining the dose rates from the roof. The data obtained are given in the form of percentages of the dose rate received three feet above an open field contaminated by the same source density. The contributions from the ground within one hundred feet of the house, beyond one hundred feet, and from the roof are shown.

Chemical Corps Engineering Command, Army Chemical Center, Maryland

39
PROTECTION OF STRUCTURES FROM CHEMICAL, BIOLOGICAL AND RADIOLOGICAL (CBR) CONTAMINATION. George P. Smith, Charles E. Bradford, Louis J. Iocca, and Henry R. Dickey. June 1959. 135p. (ENCR-30)

Basic technical information is presented on items of equipment and techniques developed by the Chemical Corps which are used to obtain Chemical, Biological, and Radiological (CBR) protection in structures. Section I outlines the purpose and scope of the report and describes the various CBR consulting services available throughout the Chemical Corps. Section II contains general requirements for protection against various forms of contamination (CW, BW, and RW) and discusses different types of existing structures and corresponding degrees of protection to which they can be remodeled. Section III contains detailed design criteria for CBR protective shelters. Discussion and illustrations of all necessary facilities and equipment are embodied. The description includes various graphs, charts, and tables showing desired pressures, air volumes, and flow characteristics. Section IV discusses the operation and maintenance of equipment incorporated in shelter design. Detailed procedures concerning establishment of optimum operating conditions are outlined in sequence of steps. Various decontaminants and their uses are also included. Section V describes available equipment for CBR protection. Photographs and drawings are included. Also embodied are equipment tables showing specifications and costs.

Chemical and Radiological Laboratories, Army Chemical Center, Maryland

40
DECONTAMINATION OF RADIOACTIVE TANTALUM DUST FROM VARIOUS ROOFING MATERIALS BY WEATHERING. INTERIM REPORT. Manfred Morganthau and Murray A. Schmoke. Dec. 2, 1953. Decl. April 27, 1959. 24p. (CRLR-308)

An experiment was conducted to determine the decontamination effects of weather on roofing materials (rolled asphalt, asphalt strip shingle, built-up tar and gravel, and corrugated steel) when contaminated with radioactive tantalum powder. The data indicate that weathering of the surfaces for 47 days removed the following percentages of radioactivity: 92% from the rolled asphalt, 40% from the asphalt strip shingle, 33% from the built-up tar and gravel, and 89% from the corrugated steel. It was determined from the results of this experiment that weather can effectively decontaminate smooth surfaces as much as 92%. Wind was the major factor contributing to decontamination; effectively 71% on rolled asphalt, and 61% on corrugated steel the first 24 hours of the test. Weathering will not effectively decontaminate rough surfaces similar to those used in this test. Upon weathering, rough surfaces pass through two stages: first, a period of contaminant redistribution followed by very gradual contaminant removal. Rain was primarily responsible for the redistribution over the rough surfaces. Residual contamination on asphalt strip and built-up tar and gravel roofs subjected to torrid weather conditions herein described cannot be reduced further by high-pressure hosing and brushing.

41
APPLICATION OF RECIPROCITY TO GAMMA-RAY SHIELDING STUDIES. Special Report covering period May 1955 to October 1955. Ralph R. Fullwood and Donald R. Roberts. Dec. 2, 1955. 19p. (CRLR-607)

The attenuation of gamma radiation by common structures is studied on the basis of reciprocating source and detector, and the solution for an infinite plane field of radiation outside of the structures is obtained by using the observation point as an influence function. The attenuation of three buildings is obtained under conventional and reciprocal techniques. Suggestions for the improvement of the agreement between the two techniques are made and the advantages of the reciprocal technique are discussed.

Cornell University, Ithaca, New York

42
THE SCHOHARIE VALLEY TOWNSITE. A PROTECTIVE COMMUNITY FOR THE NUCLEAR AGE. Jan. 1960. 59p.

The results of a study to locate and design an industrial installation and its supporting community that could remain operative during and after a thermonuclear attack are presented. Since the heart of much of the operating machinery in the second half of the twentieth century might be the electronic computer, an electronics manufacturing facility was selected as the type of installation to be studied. The site investigation was restricted to upstate New York in order to limit the scope of the problem. The Schoharie Valley, being the only rock site answering the transportation and all other criteria, was chosen for the proposed development. The structures were designed to resist nuclear explosion effects within three miles of ground zero, or 35 psi overpressure. The construction study was based on economic factors and blast, heat, and radiation resistance of the structural systems.

Corps of Engineers

43
DESIGN OF STRUCTURES TO RESIST THE EFFECTS OF ATOMIC WEAPONS. W. P. Leber. July 1, 1959. 159p. (NP-8480; EM 1110-345-413)

This manual was prepared for the guidance of engineers engaged in the design of permanent-type military structures required to resist the effects of nuclear weapons. The material is based on the results of full scale nuclear tests and analytical studies. The methods and procedures were developed through the collaboration of many consultants and specialists. In the text of this manual, references are made to interrelated subject matter in the other manuals of this series (see also EM 1110-345-414, EM 1110-345-415, EM 1110-345-416, EM 1110-345-417, EM 1110-345-418, EM 1110-345-419, EM 1110-345-420, EM 1110-345-421).

44
DESIGN OF STRUCTURES TO RESIST THE EFFECTS OF ATOMIC WEAPONS. STRENGTH OF MATERIALS AND STRUCTURAL ELEMENTS. March 15, 1957. 64p. (NP-8529; EM 1110-345-414)

This manual contains information on the strenght of structural steel, steel beams, steel columns, reinforcing steel bars, plain concrete, reinforced concrete beams, reinforced concrete columns, composite beams, reinforced concrete shear walls, reinforced concrete deep beams, and foundations. The information is based on the results of nuclear tests and analytical studies. In the text of this manual, references are made to interrelated subject matter in the other manuals of this series (see also EM 1110-345-413, EM 1110-345-415, EM 1110-345-416, EM 1110-345-417, EM 1110-345-418, EM 1110-345-419, EM 1110-345-420, EM 1110-345-421).

45
DESIGN OF STRUCTURES TO RESIST THE EFFECTS OF

REFERENCES

ATOMIC WEAPONS. PRINCIPLES OF DYNAMIC ANALYSIS AND DESIGN. March 15, 1957. 136p. (NP-8530; EM 1110-345-415)

This manual contains material on the basic principles used in dynamic analysis and design. Information is included on the analysis of single-degree-of-freedom systems, design methods for single-degree-of-freedom dynamic systems, the analysis of multidegree-of-freedom dynamic systems, the design of multistory frame buildings for plastic deformation, and the effect of variation of parameters on the response of single-degree dynamic systems. The information is based on the results of nuclear tests and analytical studies. In the text of this manual, references are made to interrelated subject matter in the other manuals of this series (see also EM 1110-345-413, EM 1110-345-414, EM 1110-345-416, EM 1110-345-417, EM 1110-345-418, EM 1110-345-419, EM 1110-345-420, and EM 1110-345-421).

46
DESIGN OF STRUCTURES TO RESIST THE EFFECTS OF ATOMIC WEAPONS. STRUCTURAL ELEMENTS SUBJECTED TO DYNAMIC LOADS. March 15, 1957. 150p. (NP-8531; EM 1110-345-416)

This manual contains information on the design of structural elements required to resist the effects of dynamic loads. Design data are included for the following: steel, reinforced concrete, and steel composite beams; reinforced concrete slabs; trusses; connections; and foundations. Methods of approximating the dynamic behavior of elements are given, and also included is a comparison of the exact and approximate solutions for simply-supported and fixed-end beams under dynamic loading. The information is based on the results of nuclear tests and analytical studies. In the text of this manual, references are made to interrelated subject matter in the other manuals of this series (see also EM 1110-345-413, EM 1110-345-414, EM 1110-345-415, EM 1110-345-417, EM 1110-345-418, EM 1110-345-419, EM 1110-345-420, EM 1110-345-421).

47
DESIGN OF STRUCTURES TO RESIST THE EFFECTS OF ATOMIC WEAPONS. SINGLE-STORY FRAME BUILDINGS. Jan. 15, 1958. 236p. (NP-6983; EM 1110-345-417)

This manual contains information on the design of permanent type single-story steel and reinforced-concrete frame structures for military use. The information is based on nuclear tests and analytical studies. In the text of this manual, references are made to interrelated subject matter in the other manuals of this series (see also EM 1110-345-413, EM 1110-345-414, EM 1110-345-415, EM 1110-345-416, EM 1110-345-418, EM 1110-345-419, EM 1110-345-420, EM 1110-345-421).

48
DESIGN OF STRUCTURES TO RESIST THE EFFECTS OF ATOMIC WEAPONS. MULTISTORY FRAME BUILDINGS. Jan. 15, 1960. 187p. (NP-8751; EM 1110-345-418)

This manual contains information on the design of multistory steel and reinforced-concrete frame structures required to resist the effects of nuclear explosions. Data are presented on the behavior of windowless, multistory, steel and reinforced-concrete rigid-frame structures under blast loads. The information is based on nuclear tests and analytical studies. In the text of this manual, references are made to interrelated subject matter in the other manuals of this series (see also EM 1110-345-413, EM 1110-345-414, EM 1110-345-415, EM 1110-345-416, EM 1110-345-417, EM 1110-345-419, EM 1110-345-420, EM 1110-345-421).

49
DESIGN OF STRUCTURES TO RESIST THE EFFECTS OF ATOMIC WEAPONS. SHEAR WALL STRUCTURES. Jan. 15, 1958. 184p. (NP-8532; EM 1110-345-419)

This manual contains information on the design of military type single-story and multistory reinforced-concrete shear wall structures. The response of shear wall structures to blast loading is discussed including behavior and resistance of the walls and sliding and overturning analyses. The information is based on nuclear tests and analytical studies. In the text of this manual, references are made to interrelated subject matter in the other manuals of this series (see also EM 1110-345-413, EM 1110-345-414, EM 1110-345-415, EM 1110-345-416, EM 1110-345-417, EM 1110-345-418, EM 1110-345-420, EM 1110-345-421).

50
DESIGN OF STRUCTURES TO RESIST THE EFFECTS OF ATOMIC WEAPONS. ARCHES AND DOMES. Jan. 15, 1960. 54p. (NP-8543; EM 1110-345-420)

This manual contains information on the design of blast resistant reinforced-concrete arch and dome structures. Design procedures for arch structures are illustrated by the design of an arch of semicircular cross section. The method may be applied to those structures whose cross is an arch of a circle or can be approximated by an arc of a circle. The domes considered are surfaces of revolution formed by revolving an arc of a circle whose center in on the axis of rotation. The information is based on nuclear tests and analytical studies. In the text of this manual, references are made to interrelated subject matter in other manuals of this series (see also EM 1110-345-413, EM 1110-345-414, EM 1110-345-415, EM 1110-345-416, EM 1110-345-417, EM 1110-345-418, EM 1110-345-419, EM 1110-345-421).

51
DESIGN OF STRUCTURES TO RESIST THE EFFECTS OF ATOMIC WEAPONS. BURIED AND SEMIBURIED STRUCTURES. Jan. 15, 1960. (NP-8793; EM 1110-345-421)

This manual contains information on the design of rectangular- and shell-type buried and semiburied structures required to resist the effects of nuclear explosions. The types of construction materials considered are steel and reinforced-concrete. The information is based on nuclear tests and analytical studies. In the text of this manual, references are made to interrelated subject matter in the other manuals of this series (see also EM 1110-345-413, EM 1110-345-414, EM 1110-345-415, EM 1110-345-416, EM 1110-345-417, EM 1110-345-418, EM 1110-345-419, EM 1110-345-420).

52
COLLECTIVE PROTECTION AGAINST CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL WARFARE AGENTS. W. P. Leber. Oct. 1, 1958. 44p. (EM-1110-345-461; NP-7313)

Fundamental principles and criteria are presented for use in the design of shelters to provide adequate and equal protection from chemical, biological, and radiological warfare agents in both gaseous and particulate form. Design criteria, drawings, and layouts are included for shelters, decontamination facilities, ventilation systems, and warning devices.

David W. Taylor Model Basin, Carderock, Maryland

53
BIBLIOGRAPHY ON SHELLS AND SHELL-LIKE STRUCTURES. William A. Nash. Nov. 1954. 75p. (DTMB-863)
Approximately 1450 papers and books pertinent to experimental and theoretical work on shells and shell-like structures are listed in this compilation. The entries are listed in chronological order, and both author and subject indexes of the papers are included. The listing is believed to be current through December 1953.

Defense Atomic Support Agency, Washington, D. C.

54
BLAST LOADING ON DOMES AND ARCHES. Fred E. Anderson, Jr. July 21, 1958. 12p. (AFSWP-522)
An analysis is presented of dome and arch loading derived from shock tube data, wind tunnel data, and data collected from Operation Plumbob, Nevada 1957.

55
DYNAMIC ANALYSIS OF A ONE STORY RIGID FRAME. R. C. DeHart. Sept. 29, 1955. 50p. (AFSWP-605)
A rigid frame subjected to time dependent forces is treated in this paper. The theoretical study consists of the use of the Lagrange equation of motion which makes possible the determination of time dependent mode shape equations. Expressions for time dependent moment are obtained from the mode shape equations. Dynamic deflection at the time plastic action begins is determined and this is compared with the static deflection required for plastic action to begin. Comparison of these results indicates that the deflection corresponding to incipient plasticity under true dynamic conditions can be much less than the deflection corresponding to incipient plasticity as determined by static load tests.

56
RESEARCH ON THE VULNERABILITY OF PETROLEUM STORAGE TANKS. Technical Analysis Report. Custer F. Krickenberger, Jr. Sept. 23, 1959. 294p. (DASA-530)
The Armed Forces Special Weapons Project, now the Defense Atomic Support Agency, has investigated the blast resistance of POL tanks. In addition, the thermal and missile damage mechanisms were reviewed. A method was derived to predict dynamic response and the resulting damage to the tanks. An analysis based on normal mode methods was made. The assumptions used in this analysis proved to be invalid because the tank began to uplift at early times. Therefore, an uplift analysis was required. A 20-ton H. E. test was held in order to verify the uplift analysis. Five 10-ft diameter tanks were tested at different pressure levels. The results for both loading and response agreed favorably with the predicted values. The experimental plan, procedure and results are discussed. A theoretical investigation of the possible modes of failure of tanks predicted that the damage mechanism would be tearing of the bottom plate at the junction of the wall. The results of a static test of 10-ft diameter tanks substantially verified the theoretical work on the damage mechanisms. The allowable strain in the bottom plate before failure takes place was determined to be approximately 0.5%. Present studies on the blast resistance of various sizes of full-scale tanks indicate that the unprotected steel tanks have a blast resistance of approximately 15 psi. Some theoretical work on thermal damage is presented.

57
THE DYNAMIC ANALYSIS OF EMPTY AND PARTIALLY FULL CYLINDRICAL TANKS. Final Report. Part II–ANALYSIS OF UPLIFT AND STRUCTURAL DAMAGE. Hans H. Bleich and Melvin L. Baron. Sept. 1959. 242p. (DASA-1123B)
Analytical methods developed to determine the response of fuel tanks to blast loads are presented. Summaries are given of the equations to be used for full scale and model tanks. Discussions are included on the possibility of obtaining the strength of typical full scale tanks from model tanks. Appendices include information on the inextensional uplift deformations of cylindrical shells, the effect of the fluid against gravity due to second order changes of volume of the tank, experiments to determine tank spillage, the flexibility of tanks, and the generalized force due to the blast forces acting on the concrete lip of the footing for concrete protected tanks.

58
THE EFFECTS OF NUCLEAR WEAPONS. Samuel Glasstone, ed. (In cooperation with the Atomic Energy Commission, Washington, D. C.). U. S. Government Printing Office. June 1957. 579p.
The general principles of nuclear explosions are reviewed and types of bursts, such as, air, surface, underwater, and underground, are described. Information is included on the effects of the various types of bursts, blast damage to structures, thermal radiation and its effects, initial radiation, residual radiation and fall-out, world-wide fall-out and long-term residual radiation, effects on personnel, and protective measures. This document is being revised and the revised edition should be available in early 1961.

Division of Biology and Medicine, Atomic Energy Commission, Washington, D. C.

59
THERMAL RADIATION MEASUREMENTS (PARTS I AND II). A. L. Greig and Hermal E. Pearse. PROJECT 39.3 [OF] OPERATION PLUMBOB–PRELIMINARY REPORT. Jan. 1958. Decl. July 30, 1959. 38p. (ITR-1502)
Attempts were made to measure the transient air temperatures at selected locations in the blast-biology underground shelter in Area 1 for Galileo Burst. No data were obtained because of failure of one recorder and loss of data in the film developing process. The equipment should be modified to be compatible with the now known conditions in close proximity of ground zero. Eight Chester white pigs were used to evaluate thermal burns from a nuclear explosion on biological receivers in a shelter. One pig in the entrance and one about 3 ft inside the door received severe burns. The burns were carbonized on the surface and caused transepidermal damage with up to 0.3 mm penetration into the dermis.

REFERENCES

Edison Electric Institute,

New York, New York

60
EFFECTS OF ATOMIC WEAPONS ON ELECTRIC UTILITIES. Ralph V. H. Wood, Arthur C. Werden, Jr., and Russell L. Berg. (In cooperation with the Office of Civil and Defense Mobilization, Washington, D. C.). PROJECT 35.1 OF OPERATION TEAPOT–PRELIMINARY REPORT. May 1955. 56p. (ITR-1173)

Duplicate electric power installations consisting of transmission, substation and distribution equipment were constructed in areas 4700 ft and 10,500 ft from ground zero on Apple II Burst. The test was to determine the following: the median survival range of the electric equipment; the extent of damage and nature of repairs required to restore disrupted service; and the ability of electric systems in comparison with the industrial plants and residential communities they serve to withstand the effects of an atomic explosion. The damage was confined to the transmission and distribution circuits at the 4700 ft area, and was of a nature most easily and quickly repaired. In the same area conventional homes were completely destroyed.

General Services Administration,

Washington, D. C.

61
THE EFFECT OF ATOMIC WEAPONS ON GLAZING AND WINDOW CONSTRUCTION. ANNEX 3.5 [OF] SCIENTIFIC DIRECTOR'S REPORT OF ATOMIC WEAPON TESTS AT ENIWETOK, 1951. OPERATION GREENHOUSE. Walton C. Clark. Aug. 1951. Decl. with deletions Dec. 28, 1954. 84p. (AECD-3643)

Various types of commercial windows glazed with plastic and different kinds of glass were installed on four sides of a test structure, which was exposed to the blast of an atomic weapon. The photographic record and detailed description of the windows before and after the blast are presented. An evaluation was also made of the comparative protection against flying glass afforded by Venetian blinds, insect screens, and mesh wire netting on the inside of window openings.

Great Britain. Home Office,

Civil Defence Department. Scientific Advisers' Branch, London, England

62
THE PENETRATION OF GAMMA RADIATION FROM A UNIFORM CONTAMINATION INTO HOUSES. A FIRST REPORT ON SOME FIELD TRIALS. A. G. McDonald. Jan. 1956. 16p. (CD/SA-69)

An experimental technique for measuring the penetration of ionizing radiation into structures has been developed by the Atomic Energy Research Establishment and the Admiralty Research Laboratory. Using this technique penetration measurements have been carried out on a small bungalow of conventional brick construction which incorporated various protective measures, so that the relative merits of such measures could be objectively measured. Data are presented graphically.

Great Britain. Home Office,

Scottish Home Department,

Edinburgh, Scotland

63
ASSESSMENT OF THE PROTECTION AFFORDED BY BUILDINGS AGAINST GAMMA RADIATION FROM FALL-OUT. 1957. 18p. (NP-6459)

A method is described for estimating the protection against γ radiation from radioactive fall-out afforded by buildings. A sample calculation is included.

Harvard University,

Air Cleaning Laboratory,

Boston, Massachusetts

64
BLAST EFFECTS ON AN AIR-CLEANING SYSTEM. C. E. Billings and Richard Dennis. PROJECT 34.4 [OF] OPERATION PLUMBBOB–PRELIMINARY REPORT. Sept. 1957. 49p. (ITR-1475)

Objectives of this project were (1) to determine the effects of blasts on filtration devices and typical gas-cleaning systems in the 3- and 1-psi over-pressure range, (2) to measure dust dislodged from AEC filters and dry plates by blast and reentrained in reverse-flow air, (3) to determine the pressure attenuation and dust-recovery characteristics of typical wire-mesh viscous filters and dry Fiberglas filters, (4) to determine the natural damping effect of duct work and stacks, and (5) to compare field and laboratory data to determine if present and future laboratory tests can be extrapolated to predict field conditions. Test results showed no damage to AEC filters and only minor damage to Fiberglas filters. Total reentrainment ranged from 73 per cent of total AEC filter loading (3.4-psi area) to 53 per cent (1.5 psi). Dry plates lost 95 per cent of their original dust holding. Prefilters recovered approximately 30 per cent of dust dislodged from AEC filters. Wire-mesh afterfilters reduced dust loss from 53 to 4.5 per cent. Field tests appear to agree with laboratory studies and indicate that future tests can be performed successfully in laboratory shock tubes.

Holmes and Narver, Inc.,

Los Angeles, California

65
AEC GROUP SHELTER. Jan. 1960. 31p. (CEX-58.7)

As a result of shelter tests and field experiments conducted over the past nine years, it has been conclusively shown that shelters provide the only promising means of civilian protection in the event of a nuclear war. Design details are presented for a group shelter to accommodate 100 persons of all age groups and both sexes. The shelter structure is a multiplate corrigated-steel arch set on a concrete slab with end walls of bridge plate sheathing. The entire structure is covered with a minimum of 3 ft of earth. The shelter combines outstanding protection against radioactive fall-out with good protection against blast and thermal radiation. Drawings are included. General operating procedures are outlined.

66
TEST OF BURIED STRUCTURAL-PLATE PIPES SUBJECTED TO BLAST LOADING. R. A. Williamson. PROJECT 34.3 [OF] OPERATION PLUMBBOB–PRELIMINARY REPORT. Nov. 1958. 44p. (ITR-1474)

Two 20-ft-long, 7-ft-diam., 10-gauge structural-plate pipes having longitudinal joints with 8 bolts per ft were buried and tested during Smoky Burst at nominal predicted pressure levels of 195 and 265 psi and at measured pressure levels of ~170 and 195 psi. Depth of burial was 10 ft. Principal measurements taken of each pipe included the transient changes in horizontal and vertical diameters vs time, vertical and radial accelerations of the pipe invert, and the maximum interior overpressure. Supplementary data included preshot and postshot measurements of horizontal and vertical diameters, joint slip, distances between end bulkheads, and elevations of the ground surface. Soil properties obtained included density, percentage of compaction, gradation, and the coefficient of internal friction. Maximum transient changes in vertical and horizontal diameters measured by the self-recording gages were ~7/8 in. and 3/8 in., respectively. Maximum residual changes in the same diameters were ~3/4 in. and 1/4 in., respectively. Discrepancies were found between measurements of residual changes recorded by the gages and those obtained visually before and after the event. Slip in bolted joints was negligible.

67
EVALUATION OF BLAST AND SHOCK EFFECTS ON TUNNEL SUPPORT STRUCTURES. Phase II Preliminary Report. A. A. Lee and E. Y. Wong. May 1959. 37p. Project 26.13 of OPERATION HARDTACK. (ITR-1714)

The underground nuclear test program of Operation Hardtack, Phase II provided an opportunity to obtain test information on the effects of underground nuclear detonations on tunnels and tunnel linings. This project was to obtain rock breakage and tunnel lining response information by normal instrumentation. Due to the re-entry and instrumentation recovery problem, most of the data obtained were static measurements from surveying and still photography. Some qualitative information was obtained by the use of deflection gages mounted on the tunnel lining, however, the gages presently recovered failed to give an adequate deflection-time trace to permit a transient response study. Tentative conclusions based on the limited data available indicate that the stress field produced by an underground nuclear detonation in tuff acts essentially as a hydrostatic load around the tunnel which would permit the use of simplified design loading for tunnel linings. Also, the configuration of the tunnel at the zero point influences the damage-distance relationships to a large degree; the straight-end configurations produced a greater damage than the hooked-end configuration. The damage-distance relationship based on previous test (Rainier) for determining the point of closure (168 $W^{1/3}$) and the point of no damage (420 $W^{1/3}$) are in close agreement with results obtained from a test in a tunnel with similar hooked-end configurations. Though the damage-distance factor for straight-end tunnels is much larger, there is also a large difference in this factor between the two events which took place in tunnels with this configuration; hence, no firm damage-distance criteria have been developed for tunnels with a straight-end configuration.

Honeywell Research Center, Hopkins, Minnesota

68
REVIEW OF THE THERMAL RADIATION PROPERTY VALUES FOR METALS AND OTHER MATERIALS. G. G. Gubareff, Shao-Yen Ko, and P. E. McNall, Jr. May 1956. 261p. (NP-8344; GR-2462-R3)

Thermal radiation property values for more than 40 metals and their alloys are given in this report. The properties reported are emissivity, absorptivity, reflectivity, and transmissivity at various surface conditions, temperatures, and wavelengths. In addition, radiation properties of building materials, paints, glasses, papers, cloths, and other miscellaneous solid materials have been compiled, and solar absorptivity and equilibrium temperatures for various materials have been tabulated. These values have been gathered from about 200 references in English, German, French, and Russian and have been carefully analyzed to obtain, in the authors' opinion, the most trustworthy data for practical application. Recommended data for technically important materials are also presented graphically. An extensive survey was conducted to compile values for Stefan-Boltzman's, Planck's, and Wien's constants, and the most reliable values for practical application are listed in a separate table. The thermal radiation equations are introduced, and a short discussion of the basic mechanism of heat transfer by radiation and the general tendencies of thermal radiation properties is given. Definitions of the radiation properties and their mutual relationships are also included.

Illinois Institute of Technology. Armour Research Foundation, Chicago, Illinois

69
SHIELDING OF THREE-DIMENSIONAL BLOCKS. Final Test Report No. 2. (In cooperation with the Wright Air Development Center, Wright-Patterson Air Force Base, Ohio). November 1955. Decl. Aug. 13, 1957. 18p. (AFSWP-989; ARF-MO69, No. 22)

A test program on shielding was conducted in the Armour Research Foundation operated Shock Tube Laboratory in Gary, Indiana, in order to obtain information about the order of magnitude on shieldings between two identical three-dimensional models spaced at various distances. Primacord was used to create peaked blast waves, which were utilized to load solid cubicals instrumented with barium titanate pressure sensors. This series of tests represents the first major tests which were conducted in the 6-foot diameter shock tube, and as a result, valuable experience in test design and instrumentation techniques, as well as methods of data reduction, has been gained. Unfortunately, not all the data taken was consistent enough to be reported upon; however, for one particular test series, data of sufficient reliability was obtained. This data was utilized to deduce the impulse on the shielded models for separations as high as 6 times their common height and, for width-to-height ratios, ranging from 3:2 (three-dimensional) to 9:2 (nearly two-dimensional). For the particular peakedness factor studied, $\tau_0 \approx 160$, the diffraction phase was negligible compared to the drag phase. It was found that the shielding factor fell roughly half way between the shielding of extremely peaked waves ($\tau_0 < 10$) and the steady-state case ($\tau_0 \rightarrow \infty$). Shielding became negligible at roughly one-half the separation distance of the steady-state case.

70
BLAST EFFECTS ON BUILDINGS AND STRUCTURES–OPERATION OF SIX-FOOT AND TWO-FOOT SHOCK TUBES. A. Ritter and T. H. Schiffman. (In cooperation with the Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.). Aug. 1955. 21p. Decl. Aug. 13, 1957. (AFSWP-992; ARF-MO69 No. 18)

An exploratory investigation was conducted to demonstrate on a gross basis the reduction in peak overpressure which will produce a given maximum deflection of an elastic-plastic structure as the positive phase duration of blast loading is increased. Test structures were subjected to blast waves of approximately 10 and 20 msec positive phase durations and approximately 20 and 10 psi peak overpressures, respectively. Although no quantitative conclusions could be drawn as to exact pressure reduction factors because of limited accuracy and small number of tests, the results indicate substantial pressure reductions with increased duration loadings for the test structures under consideration.

71
BLAST EFFECTS ON BUILDINGS AND STRUCTURES–OPERATION OF SIX-FOOT AND TWO-FOOT SHOCK TUBES. Final Test Report No. 4. EXPERIMENTAL OBSERVATIONS OF REGULAR REFLECTION LOADINGS ON THREE-DIMENSIONAL BLOCKS. A. H. Wiedermann and T. H. Schiffman. Jan. 4, 1956. Decl. Aug. 13, 1957. 51p. (AFSWP-993)

The test program on regular reflection loading was conducted in the Shock Tube Laboratory, Gary, Indiana, which is operated by the Armour Research Foundation, in order to obtain a comparison between the loading observed on three-dimensional blocks and the loading computed from the prediction methods for two-dimensional blocks. Primacord was used to generate peaked blast waves which were incident upon a tilting plate on which the model was located. Observation times were limited to the diffraction phase of the loading since signals from the walls of the shock tube eventually disturbed the flow field near the models. Observations of the average pressures on the front, top, and back surfaces of two blocks were observed at two angles of incidence ($\alpha = 20$ and $45°$) and at an incident shock strength of 1.33 ($p'\sigma$ (0) = 5 psi). Both models were 3 inches high, 6 inches wide, but one was 3 inches long and the other, 6 inches long. The comparisons between the observed and predicted loadings were satisfactory, i.e., the deviation of the observed loading from two-dimensional theoretical loadings were in the anticipated direction and were not large enough to warrant any modification of the two-dimensional theory.

72
BLAST EFFECTS ON BUILDINGS AND STRUCTURES–OPERATION OF SIX-FOOT AND TWO-FOOT SHOCK TUBES. Final Test Report No. 6. BASIC LOADING ON M.I.T. MULTI-STORY STRUCTURES IN THE REGULAR REFLECTION REGION. G. T. Tzantzos, T. H. Schiffman, and A. H. Wiedermann. March 22, 1956. Decl. Aug. 13, 1957. 38p. (AFSWP-1021)

A test program on loading of multi-story structures in the regular reflection regions was conducted in the Air Force Shock Tube Laboratory located at Gary, Indiana, which is operated by the Armour Research Foundation. Three- and four-story M.I.T. models, struck by shock waves at 20-degree and 0-degree angles of incidence respectively, were instrumented on all surfaces and provided the basic loading information necessary for establishing a load prediction method for two-dimensional multi-story structures located in the regular reflection region. Primacord was used to generate peak blast waves which were incident upon a tilting plate on which the models were located. Observations were limited to approximately 3 milliseconds, a time interval sufficiently long to observe the diffraction phenomena; after that time, signals from the walls of the shock tube disturb the flow field in the neighborhood of the models. Since the drag phase is insignificant compared to the diffraction phase for the small angles of incidence treated, the observed pressure-time variation is indeed sufficient to provide all the necessary loading information for damage prediction. It was found that the gross phenomena such as maximum pressure, build-up and relief times, vortex formation, etc., are quite similar for the 20-degree and 0-degree incidence cases. This test series was very successful and consistent data was obtained throughout the program.

73
BLAST EFFECTS ON BUILDINGS AND STRUCTURES–OPERATION OF SIX-FOOT AND TWO-FOOT SHOCK TUBES. Final Test Report No. 7. EXPERIMENTAL OBSERVATIONS OF INTERIOR PRESSURES IN HOLLOW MODELS. T. Schiffman and A. Wiedermann. July, 1956. Decl. Aug. 9, 1957. 36p. (AFSWP-1022)

A test program on hollow models was conducted in the Air Force Shock Tube Laboratory, Gary, Indiana in order to obtain pressure-time data on the interior of the structures. Primacard was used to generate peak blast waves. Hollow models, of 4-inch height, were utilized with a height-to-width-to-length ratio of $1:1\frac{1}{2}:3$ and with nominal openings on the front, roof, sides, and back of 0, 30, or 100 per cent with no interior obstacle and with one and two interior obstacles. The incident shock was approximately 5.0 pounds per square inch, equivalent to a shock strength of 1.34 and had a duration of 22 milliseconds, equivalent to a peakedness factor based on the length of the model $Ut_0/L = 25$. Calculated were the average initial interior overpressure and the average maximum interior pressure for the empty model, and the impulses delivered to the interior obstacles. It was found that the initial and maximum pressures in the hollow model do not vary appreciably as a function of position for a given configuration and that the front opening is the most influential and the back opening the least influential in determining their values. The total impulse delivered to the interior obstacle(s) were, in most cases, greater than that which the obstacle(s) would have experienced had it been located outside of the hollow model.

74
BLAST EFFECTS ON BUILDINGS AND STRUCTURES. OPERATION OF SIX-FOOT AND TWO-FOOT SHOCK TUBES. ARF Project No. DO87, Report No. 38. EFFECT OF WALL PANEL FAILURE ON SHOCK PARAMETERS. (Final Test Report No. 8). T. A. Zaker. Feb. 1956 through July 1956. Decl. Aug. 13, 1957. (AFSWP-1023)

Measurements were made in a shock tube of side-on pressure build-up in the interior of a model structure when failure of a frangible upstream wall panel occurred. The brittle but flexible materials which comprised the frangible panels have the essential characteristics of a large class of exterior wall coverings. Two materials in four thickness, ranging from about 1/100 to 1/25 of the short span, were subjected to blast waves having side-on overpressures from 5 to 60 psi. Maximum interior pressure, rise time of the interior compression wave, and time of failure of the panel were measured in each test. The results are given in a generalized graphical form as functions of blast and structural response parameters. Static resistance properties of the panels were found from static load-center deflection data obtained experimentally.

75
BLAST EFFECTS ON BUILDINGS AND STRUCTURES OPERATION OF SIX-FOOT AND TWO-FOOT SHOCK TUBES. BLAST EFFECTS ON TANK STRUCTURES. Final Test Report No. 16. G. Nagumo. 138p. (DASA-1154; AD-233095)

A test program on cylindrical tank type structures was conducted in the Air Force Shock Tube Laboratory, Gary, Indiana, in order to obtain pressure-time loading data. Several cylindrical tank models were tested at a peak overpressure of 20 psi and a positive duration of 35 msec. Model parameters tested included cone roof models, floating flat roof models (0.1, 0.5, and 0.9 full), models with and without windgirders and with three different height-to-diameter ratios. Loading schemes were obtained for the various exposed surfaces of the above models and some comparisons were made between the different model configuration parameters.

76
FEASIBILITY OF TUNNEL CLOSURES. Final Report. Ralph L. Barnett and R. W. Sauer. Aug. 1958. Appendix A: PHENOMENOLOGY. M. A. Chaszeyka, F. B. Porzel, and T. H. Schiffman. Appendix B: BLAST DOOR LOADING. E. V. Gallagher and G. J. Tzantzos. Appendix C: DESIGN OF BLAST-RESISTANT TUNNEL DOORS. E. L. Cohen and R[alph] L. Barnett. Appendix D: MECHANICS OF DOOR CLOSURE. M. J. Shoelson. APPENDIX E: DESIGN OF CONCRETE TUNNEL WALLS AND PARTITIONS. T. S. Dickerman and R[alph] L. Barnett. 163p. (NP-7242)

The objective of this program was to determine the feasibility of designing tunnel closures to resist the pressures resulting from nuclear detonations in close propinquity to horizontal continuous tunnels. A 30-ft diameter circular tunnel, which has a longitudinal centerline lying 40-ft below the ground surface was studied. Upper bounds on the pressure inside of the tunnel are determined for a 1-MT and a 20-MT nuclear device detonated on the surface directly over the tunnel. The pressures resulting from the detonation of these weapons inside the tunnel were found to occur at approximately the same distances from ground zero as the corresponding pressures from the surface bursts. Effective closures were designed for the internal and surface bursts at distances from ground zero; corresponding to the location of the 30-psi and 100-psi outside overpressure levels which result from a surface burst. The structural forms found to be feasible for the closure applications included one-way and two-way steel slabs and hemispherical membranes.

77
EVALUATION OF DEEP TUNNEL SHELTERS. Final Report. K. E. McKee and R. W. Sauer. Nov. 1958. 97p. (NP-7243)

The results are given of an evaluation to determine the vulnerability to nuclear detonations of deep tunnel shelter systems below major cities. The final presentation gives the combination of weapon yield and depth of tunnels associated with various levels of damage. The vulnerability is considered for both the proposed shelter system and for individual tunnels. Primarily, attention is given to the shelters proper, although some consideration is given to the entranceways and utilities.

University of Illinois, Urbana, Illinois

78
SLOW AND RAPID LATERAL LOADING TESTS OF SIMPLY SUPPORTED BEAMS AND BEAM-COLUMNS. R. F. Wojcieszak and J. M. Massard. (In coperation with the Air Force Special Weapons Center, Air Research and Development Command, Kirtland Air Force Base, New Mexico.) Feb. 1957. 106p. (AFSWC-TR-57-21; AD-144532)

The two major purposes of the program described in this report were to determine experimentally the resistance of several beam and beam-column specimens to inelastic deformations applied slowly and rapidly; and, if possible, to correlate these resistances with the static and dynamic properties of the materials from which the specimens were made. The results obtained indicate that, beyond the static elastic limit, the resistance of a mild steel beam or beam-column to a lateral displacement produced rapidly is greater than that corresponding to the same lateral displacement produced slowly; and that the increase in the resistance of a beam with the rapidity of the lateral deformation can be explained, within reasonable limits not greatly exceeding experimental error, by consideration of the experimentally determined dynamic properties of the specimen material which included delayed yielding and rate of general yielding behaviors typical of mild steel.

79
AN INVESTIGATION OF RIVETED AND BOLTED COLUMN-BASE AND BEAM-TO-COLUMN CONNECTIONS UNDER SLOW AND RAPID LOADING. D. McDonald, A. Ang, and J. M. Massard. (In cooperation with the Air Force Special Weapons Center, Air Research and Development Command, Kirtland Air Force Base, New Mexico). Feb. 1958. 138p. (AFSWP-1067; AD-144531; AFSWC-TR-58-5)

A description is given of slow and rapid load tests of riveted and bolted column-base and beam-to-column connections, and the results which were obtained are included. Measurements of load, deflection, strain, and acceleration were taken in order to evaluate the resistance characteristics of the connections. The results indicate that the rate of deformation had an effect on the resistance of the connection; rapidly deformed specimens had a greater resistance at a given deflection than those tested slowly. The type of fastener, rivet or high strength bolt, had little on the moment-rotation characteristics of the connections studied. With respect to the evaluation of specific moment resistance characteristics of connections subjected to rapid loading, this limited pilot study served only to indicate the nature of the resistance function which could be expected for connections of type tested. Also presented is a procedure for evaluating the resistance of a frame with semi-rigid connections as it is loaded into the inelastic range. The method of analysis is such that the resistance characteristics of the connection, as well as that of the members, are taken into consideration.

80
EFFECT OF LONG POSITIVE PHASE BLAST WAVES ON DRAG AND DIFFRACTION TYPE TARGETS. N. M. Newmark. Aug. 1953. 11p. (AFSWP-494)

REFERENCES

Calculations of the relative pressures required to produce collapse, or large deflections, of simple structural types subjected to the blast from nuclear detonations of various sizes ranging upward from 20 kt are summarized. Included are relative values of the "side-on" overpressures p_s which are required to produce collapse of structures in the brittle and in the ductile range for three different natural periods of vibration in the range of values which cover most practical cases. The overpressures are recorded as ratios of those required for a 20 kt weapon. Empirical equations are also included to permit the calculation to be extended to other cases of interest.

81
DESIGN OF UNDERGROUND STRUCTURES TO RESIST NUCLEAR BLAST. VOLUME II. Final Report. (Civil Engineering Studies—Structural Research Series No. 149). J. L. Merritt and N. M. Newmark. (In cooperation with the Office of the Chief of Engineers, U. S. Army) Apr. 1958. 119p. (NP-7854)

Recommendations and procedures are presented for use in the design and construction of underground protective structures. It is assumed the structures will be subjected to nuclear blast loadings in the megaton range. Data from analytical and experimental studies used in developing the design criteria are included. The propagation of shock waves through soils and the mechanical properties of structural steels and reinforced concrete are discussed. Criteria are included for a hypothetical building.

82
DEVELOPMENT OF PROCEDURES FOR RAPID COMPUTATION OF DYNAMIC STRUCTURAL RESPONSE. Structural Research Series No. 171. J. W. Melin and S. Sutcliffe. Jan. 1959. (NP-9148)

Information is presented on the development of rapid, reliable methods of relating the response of structures and structural elements to the blast loads from nuclear weapons. The major concern was with structures which could be satisfactorily idealized as single-degree-of-freedom systems because of their prevalance; however, consideration was also given to those structures which respond to blast loads in more than one mode, that is, multi-degree-of-freedom systems. The essence of this report is a rapid technique which was developed for the analysis of a single-degree-of-freedom system with a resistance function which can be idealized as an elasto-plastic function, and which is loaded with an initially peaked triangular force pulse. Simple but quite accurate techniques were developed for the analysis of single-degree-of-freedom systems having elasto-plastic resistance functions subjected to load pulses other than the initially peaked triangular force pulse considered in the basic problem. Methods are presented for the rapid but reliable analysis of any single-degree-of-freedom system having any bilinear resistance function subjected to any of a wide variety of force pulses. Hypothetical problems illustrating the techniques developed are presented and a number of representative structures subjected to blast forces are analyzed to illustrate the applicability of the methods developed herein to such problems.

Johns Hopkins University, Operations Research Office, Chevy Chase, Maryland

83
BLAST LOADING OF MULTI-STORIED STRUCTURES OF FIRMO-VISCOUS TYPE. W. H. Hoppmann II, N. J. Huffington, Jr. July 1952. 17p. (ORO-T-198)

An analytical investigation was made of the deformation of two types of structures assumed to have internal resistance of the firmo-viscous type and to be subjected to side blast loading. The first is a multistoried building consisting of a series of massive floors each of which is supported atop shear frames connecting the successive floors. The second is a pile of rigid blocks cemented together, intended to simulate massive blocks of masonry attached to each other by a viscous material. Numerical examples illustrating the theory are treated.

84
BLAST LOADING OF WALLS. N. J. Huffington, Jr. and W. H. Hoppmann, II. July 1952. 33p. (ORO-T-199)

The deflections and strains from free and forced vibrations in rectangular plates were investigated. The theory of thin elastic plates was used and the solution is applied to the problem of the blast loading of a wall. Results indicate that simplified methods of calculation may be derived to provide accuracies sufficient for engineering purposes without excessive consumption of time.

Knolls Atomic Power Laboratory, Schenectady, New York

85
CALCULATION OF FREQUENCIES AND MODE SHAPES FOR MULTI-DEGREE OF FREEDOM SYSTEMS USING THE IBM 650 COMPUTER. Mary C. Ray. Nov. 25, 1959. 39p. (KAPL-M-MCR-1)

A means of computing the normal mode shapes and frequencies for structure response to applied load is presented. The computation can be done by the IBM 650 magnetic drum data-processing machine. With the mass and influence coefficient (flexibility) matrices as input, the machine computes all the frequencies and mode shapes; these are the eigenvalues and eigenvectors. Limitations of the method are discussed and examples to show code operation are given.

86
A GENERALIZATION OF CUMULATIVE DAMAGE. R. M. Mains. Oct. 6, 1958. 28p. (KAPL-M-RMM-3)

In the application of various damage accumulation hypotheses to shock and vibration problems, a pattern of results was observed. A plot of allowable response (for the largest of a sequence of excitations) versus the number of excitations in the sequence produced straight lines on log-log paper for each value of damping. It seemed likely that a generalization could be found which would relate the allowable response to the largest excitations with a load-distribution factor, a material-and-structure factor, and the material constants from fatigue tests. One form of this generalization is presented, together with some numerical examples of its use and a discussion of its possible significance.

Lehigh University, Fritz Laboratory, Bethlehem, Pennsylvania

87
LITERATURE SURVEY ON LATERAL INSTABILITY AND

LATERAL BRACING REQUIREMENTS. Interim Report No. 43 on WELDED CONTINUOUS FRAMES AND THEIR COMPONENTS. FRITZ LAB. REPORT 205H.2. George C. Lee. Oct. 1959. 58p. (NP-8245)

This literature survey is limited to a general survey of the existing solutions to the problem of lateral buckling of metal structures, with emphasis on three points. Point number one is an extensive list of references including those that may be helpful for the lateral bracing problem. Number two is a description of several important papers particularly concerned with inelastic solutions. Number three gives a general historical sketch of the problem of lateral instability.

Liquefied Petroleum Gas Association, Chicago, Illinois

88

EFFECTS OF A NUCLEAR EXPLOSION ON TYPICAL LIQUEFIED PETROLEUM GAS (LP GAS) INSTALLATIONS AND FACILITIES. Paul W. Tucker and George R. Webster. (In cooperation with the Office of Civil and Defense Mobilization, Washington, D. C.). PROJECT 35.4a [OF] OPERATION TEAPOT. Dec. 1956. 45p. (WT-1175)

This project was designed to determine the effect of a nuclear explosion on typical liquefied petroleum gas (LP gas) containers and systems as found at the home and at storage, industrial, or utility plants and to determine the reliance which might be placed on LP gas as an emergency fuel in the event of such an attack. The installations and facilities were exposed to Apple II Burst. Two types of home (or small commercial) LP gas installation were tested: the dual 100-lb cylinder systems and the 500-gal bulk systems. These were placed at four different distances from ground zero where the damage was expected to range from complete destruction to light damage. A complete 18,000-gal bulk storage plant and cylinder-filling building were constructed in the middle of the expected severe damage zone. The test indicated that LP gas equipment is very rugged except for the soft copper tubing and that where a house remained standing the LP gas system was intact and where the house was demolished the LP gas equipment was, for the most part, salvageable and could be made ready for use with but minor repairs. The cylinder-filling building was demolished, but the 18,000-gal bulk storage tank with attendant pipe, fittings, etc., was intact, and the gas was immediately available for use.

Los Alamos Scientific Laboratory, Los Alamos, New Mexico

89

PAPERS PRESENTED AT THE CONFERENCE ON ATOMIC ENERGY EDUCATION [HELD] AT THE UNIVERSITY OF NEW MEXICO [ON] Oct. 17 and 18, 1952. (AECU-2537)

Papers presented at the Conference on Atomic Energy Education at the Univ. of N. Mex. on the following subjects are reproduced: Possible Uses of Nuclear Power; Atomic Blast Effects on Buildings and Structural Dynamics; (Hiroshima and Nagasaki structures); Uranium Exploration; Separation of U Isotopes; Industrial Power from Nuclear Energy; Radioisotopes for Industrial Research and Application.

Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico

90

BIOLOGICAL EFFECTS OF BLAST FROM BOMBS. GLASS FRAGMENTS AS PENETRATING MISSILES AND SOME OF THE BIOLOGICAL IMPLICATIONS OF GLASS FRAGMENTED BY ATOMIC EXPLOSIONS. Progress Report. I. Gerald Bowen, Donald R. Richmond, Mead B. Wetherbe, and Clayton S. White. June 18, 1956. 48p. (AECU-3350)

An exploratory study was made whose aim was to evaluate the damage done by low velocity (less than 1000 ft/sec) missiles consisting of small fragments of ordinary window glass striking in random orientations a biological target. The index of damage was chosen to be the penetration of the abdominal wall of anesthetized dogs. By use of appropriate laboratory data, a criterion of penetration was derived which expresses in equation form the probability of penetration criterion was applied individually to data for 2486 glass missiles originating in test houses placed on Operation Teapot at various ranges from ground zero. By use of other statistical procedures, expectation of penetration was computed as a function of overpressure for the region between 1.9 and 5.0 psi. It was found that maximum expectation occurred at about 3.8 psi. The general biological significance of the results obtained was discussed.

91

THE INTERNAL ENVIRONMENT OF UNDERGROUND STRUCTURES SUBJECTED TO NUCLEAR BLAST. I. THE OCCURRENCE OF DUST. Preliminary Report. Clayton S. White, Mead B. Wetherbe, and Vernon C. Goldizeh. PROJECT 33.5 [OF] OPERATION PLUMBBOB–PRELIMINARY REPORT. Sept. 1957. 69p. (ITR-1447)

The possible occurrence of dust inside protective shelters as a consequence of nuclear explosions was studied using 18 underground structures subjected to atomic detonations during Bursts Smoky, Galileo, and Priscilla at distances ranging from 4320 to 840 ft from ground zero. The existence of considerable dust was established using stick-tray fallout collectors. Particulates captured arose from dust on the floor existing preshot, from "dust leaks" in some shelters, and from the internal surfaces of the structures. The latter was established by treating the walls and ceilings of selected shelters with a fluorescent dye solution and subsequently demonstrated fluorescence of captured particles. Data available indicate that the dust-collector technique will be useful in evaluating the environmental aspects of shelters tested in the future and that procedures showing fine spalling may be more sensitive indicators of structural response to dynamic loading than gross spalling. Should this indeed be established, the florescent method employed, or an equivalent, will become another simple routine test available to indicate structural response at greater ranges than is now possible without using complicated instrumentation.

92

DISTRIBUTION AND DENSITY OF MISSILES FROM NUCLEAR EXPLOSIONS. I. Gerald Bowen, Allen F. Strehler and Mead B. Wetherbe. PROJECT 33.4 [OF] OPERATION PLUMBBOB. Mar. 1956. 113p. (WT-1168)

A new experimental procedure was used in the open shot of Operation Teapot to study various properties of secondary missiles produced in houses, shelters, and open areas at distances of 1470 to 10,500 ft from a nuclear explosion with a yield approximately 50 per cent greater than nominal. The experimental technique involved trapping the missiles in an absorbing material consisting of Styrofoam 22. Laboratory calibrations of the Styrofoam made it possible to determine individual velocities for the trapped missiles. Velocities were calculated for 2611 missiles—95 per cent of which were window-glass fragments—obtained from 27 traps. Missile velocities, masses, and spatial distributions were analyzed statistically. Computational procedures were proposed to predict the velocities of stone missiles in open areas from blast data and from assumed average aerodynamic constants for stones. The method was tested for the 5-psi overpressure region. The computed predicted velocities showed satisfactory correspondence with those empirically determined from data obtained from a missile trap placed in this region.

93
BIOLOGICAL EFFECTS OF PRESSURE PHENOMENA OCCURRING INSIDE PROTECTIVE SHELTERS FOLLOWING A NUCLEAR DETONATION. C. S. White, I. Gerald Bowen, D. R. Richmond, Vernon C. Goldizeh, F. Sherping, J. T. Parker, T. L. Chiffelle, M. E. Cribbe, D. E. Kilgore, W. H. Lockyear, B. B. Longwell, H. W. Merideth. PROJECT 33.1 [OF] OPERATION TEAPOT. Oct. 1956. 219p. (WT-1179)

In two series of experiments 277 experimental animals, including 66 dogs, 52 rabbits, 52 guinea pigs, 63 rats, and 44 mice, were exposed under selected conditions in six different general types of instrumented above-and below-ground shelters to blast produced by nuclear explosions. The distance of the structures from ground zero ranged from 1050 to 5500 ft. Variations in the overpressure-time phenomena inside the structures ranged from maximal pressures of 1.3 psi enduring for 1346 msec to 85.8 psi lasting for 570 msec. The times of pressure rise ranged from 4.0 to 420 msec. Following the explosions, all animals were recovered, examined, sacrificed, and subjected to gross and microscopic pathological study. All lesions were tabulated and described. A discussion is included of pressure environment and related pathology. A critical review of selected material from the blast and related literature is presented. All data are discussed, and the several problems related to the design and construction of protective shelters are noted and briefly, but analytically, assessed. The most outstanding contribution of the field experiments and the related study of the literature was the unequivocal demonstration that the provision of adequate protective structures can be an effective means of sharply reducing casualties which would otherwise be associated with the detonation of modern large-scale explosive devices.

94
BLAST BIOLOGY—A STUDY OF THE PRIMARY AND TERTIARY EFFECTS OF BLAST IN OPEN UNDERGROUND PROTECTIVE SHELTERS. D. R. Richmond, C. S. White, I. Gerald Bowen, Mead B. Wetherbe, Vernon C. Goldizeh, R. T. Sanchez, F. Sherping, J. G. Riley, T. L. Chiffelle, V. R. Clare, F. G. Hirsch, M. L. Kuhn, B. B. Longwell, R. V. Taborelli, and J. D. Ward. PROJECT 33.1 [OF] OPERATION PLUMBBOB. FINAL REPORT. Feb. 1959. 68p. (WT-1467)

Dogs, pigs, rabbits, guinea pigs, and mice were exposed in two open underground partitioned shelters each 1050 ft from a separate nuclear detonation. An aerodynamic mound was placed over the escape hatch of each structure to determine its effects on the pressure-curve shape inside the chamber. In one test a seive plate bolted across the top of the mound was evaluated. Wind protective baffles of solid plate and heavy wire screen were installed in shelters to compare primary and tertiary blast effects on dogs. The shelters also contained static and dynamic pressure gages, radiation detectors, telemetering devices, and, in one test, air-temperature measuring instruments, dust-collecting trays, and eight pigs for the biological assessment of thermal effects. One dog was severely injured from tertiary blast effects associated with a maximal dynamic pressure (Q) of 10.5 psi, and one was undamaged with a maximal Q of 2 psi. The mortality was 19% of the mice exposed to a peak pressure of 30.3 psi and 5 and 3% of the guinea pigs and mice exposed to a peak pressure of 25.5 psi. Following Burst Franklin, thermal effects were noted. Animals of the groups saved for observation have died from ionizing-radiation effects.

95
THE INTERNAL ENVIRONMENT OF UNDERGROUND STRUCTURES SUBJECTED TO NUCLEAR BLAST. II. EFFECTS ON MICE LOCATED IN HEAVY CONCRETE SHELTERS. D. R. Richmond, C. S. White, R. T. Sanchez, and F. Sherping. Sept. 1959. 24p. Project 33.6 of OPERATION PLUMBBOB. (WT-1507)

A cage containing 20 mice was placed in each of 12 underground shelters tested on Burst Smoky in an attempt to assess biologically the inside environment of the shelters. Two samples of 20 mice each acted as controls. The structures, of French and German design, were located at ranges between 840 ft and 4320 ft from ground zero. Burst Smoky, a nuclear device, was exploded atop a 700-ft tower and had a yield of 43 kt. All but one group of mice were recovered on D + 2 days. Aside from two samples placed in unrealistic locations, all animals were alive at recovery. With one exception, the peak pressures in the chambers that contained mice were in significant, ranging from a fraction of 1 psi to 1.6 psi. The one high pressure of 14.4 psi did not kill any of the mice. According to the film-badge dosimeters, one group of mice received 190 r of gamma radiation. The others were exposed to 54 r of gamma or less. The mice were observed for a 60-day postshot period. The deaths that occurred were attributed to a Salmonella infection in the animal colony and not to radiation. Although the gamma radiation doses that most of the animal groups received were low, the levels that existed in the main chambers near the entry doors of the German shelters were over 100 r, a biologically significant dose. In contrast, the environment within two of the French shelters appeared to be quite acceptable.

Manhattan District, Atomic Bomb Investigating Groups

96
THE ATOMIC BOMBINGS OF HIROSHIMA AND NAGASAKI. [Survey conducted by the Manhattan Project Atomic Bomb Investigating Group, Sept. 1945] 1946, 48p.

The effects of the nuclear bombs which were dropped on the Japanese cities of Hiroshima and Nagasaki on August 6 and 9, 1945, respectively, are described. Information on damage to structures, injuries to personnel, and morale effect is summarized. (See also Photographs of the Atomic Bombings of Hiroshima and Nagasaki).

97
PHOTOGRAPHS OF THE ATOMIC BOMBINGS OF HIROSHIMA AND NAGASAKI. [Survey conducted by the Manhattan Project Atomic Bomb Investigating Group, Sept. 1945] 1946, 101p.
A photographic summary of the effects of the nuclear bombs which were dropped on the Japanese cities of Hiroshima and Nagasaki on August 6 and 9, 1945, respectively, is presented. (See also The Atomic Bombings of Hiroshima and Nagasaki).

98
This reference is intentionally omitted.

99
PHYSICAL DAMAGE, HIROSHIMA, JAPAN. Noland Varley. [Survey conducted by the Manhattan Project Atomic Bomb Investigating Group, Sept. 1945] Vol. I, 39p. Vol. II, 77p. Decl. May 8, 1956. (NP-9923)
The extent of physical damage to structures, caused by the Hiroshima nuclear explosion, is reported. The following types of structures are discussed: timber-framed buildings, reinforced-concrete framed buildings, steel-framed mill-type buildings, buildings with load-bearing walls, public utilities, and bridges. Photographs are included of the city and damaged structures. This report is contained in two separately bound volumes. (See also Nagasaki Atomic Bomb Damage).

100
NAGASAKI ATOMIC BOMB DAMAGE. Walter C. Youngs, Jr. [Survey conducted by the Manhattan Project Atomic Bomb Investigating Group, Sept. 1945] Vol. I, 62p. Vol. II, 62p. 1946. Decl. June 1, 1956. (NP-9925)
The extent of damage to buildings, bridges, chimneys, and other structures, caused by the Nagasaki nuclear explosion, is reported. The following information is included: A description of Nagasaki, a description of the nuclear explosion, information on types of structures and utilities damaged, and the response of blast-resistance structures. This report is contained in two separately bound volumes. (See also Physical Damage, Hiroshima, Japan).

Massachusetts Institute of Technology.

Department of Civil and Sanitary Engineering, Cambridge, Massachusetts

101
BEHAVIOR OF WALL PANELS UNDER STATIC AND DYNAMIC LOADS. John M. Cord, Jack Kinstlinger, John S. Archer, and Robert J. Hansen. (In cooperation with the Office of the Chief of Engineers Department of the Army) Jan. 1954. 156p. (AFSWP-113)
Laboratory tests were made in order to obtain data on the behavior of wall panels under static and dynamic loads. The tests were performed on beams and panels made of several materials commonly used as wall panels, including brick masonry, reinforced brick masonry, brick masonry with reinforced gunite, concrete block, partition tile, asbestos-cement siding, and metal siding. The experimental techniques and test results are discussed. Also included is a discussion of a method of interpretation of the test results for the purpose of design of wall panels or the analysis of the response of wall panels to the blast from a nuclear weapon.

102
AN INVESTIGATION OF THE VARIATION OF STRUCTURAL PARAMETERS OF SINGLE STORY STEEL FRAME INDUSTRIAL BUILDINGS. George P. Turci and Robert J. Hansen. Jan. 16, 1957. 64p. (AFSWP-783)
An investigation of the variation of structural parameters associated with single-story steel-frame industrial buildings is presented. The parameters which are of direct concern in this study are those which are pertinent in an investigation of the dynamic behavior of buildings of the type mentioned. These parameters include effective mass, effective area exposed to load, resistance, maximum equivalent elastic deflection, and natural period of vibration. Information relating to the various parameters was obtained from engineering drawings for a number of existing buildings. Evaluation of the parameters was accomplished by determination of the physical characteristics and static analysis of the structural components of which each building is constituted. Simplified methods were utilized in connection with that static analysis of the buildings considered in this study. Results are compared in order to determine the existence of correlations involving the various parameters and the best correlations are presented in the form of curves.

103
THE THEORETICAL ELASTIC RESPONSE OF SHEAR WALLS SUBJECTED TO DYNAMIC LOADS. Aaron Finerman and Robert J. Hansen. Aug. 1956. 168p. (AFSWP-818)
Information is presented on the theoretical behavior of shear walls subjected to impulsive loads. Although the theoretical derivation are in most cases perfectly general, results have been obtained for a limited number of reinforced concrete walls. To perform the analysis the actual walls were replaced by a series of lumped masses interconnected by massless springs. The dynamic response of three different size walls subjected to two different rates of load build-up was ascertained within elastic limit of the behavior. In addition, two different grid sizes of the dynamic model were investigated. The entire analysis was performed on the Massachusetts Institute of Technology high speed digital computer Whirlwind I.

104
AN INVESTIGATION OF THE VARIATION OF STRUCTURAL PARAMETERS OF MULTISTORY REINFORCED CONCRETE FRAME BUILDINGS. John S. N. Daniel, Robert J. Hansen. Feb. 1957. 60p. (AFSWP-1005)
An investigation of the variation of structural parameters associated with multistory reinforced concrete frame structures is presented. The parameters which are of direct concern in this study are those which are pertinent in an investigation of the dynamic response of the structures to blast loads. These parameters include effective mass, effective area exposed to load, partitions subject to blast loads, and column strength. The characteristics which have a direct bearing on the dynamic response were evaluated by inspection of the architectural and structural drawings of the buildings. The strength characteristics of the reinforced concrete column were analyzed. The plastic theory of reinforced concrete design which provides a simple consistent method for determining the ultimate axial load and moment capacity of rectangular and circular

reinforced concrete sections for any combination of thrust and moment was used. The results are compared in order to determine the existence of correlations involving the various parameters and are presented in the form of curves.

105
THE RESPONSE OF CONCRETE SHEAR KEYS TO DYNAMIC LOADING. Edward G. Nawy and Jayantilal M. Shah. Jan. 1959. 65p. (AECU-4562)
A program for determining the behavior of concrete shear keys under dynamic loading similar to that encountered in nuclear blasts and the behavior of these keys under static loading are described. Results indicate that concrete keys can withstand stresses in pure shear as high as 2000 psi and that the keys exhibit higher shear strength when subjected to dynamic loads than when stressed by static loads. Tests also indicate that the strength and quality of the gravel are probably major factors governing the strength of the keys.

106
BEHAVIOR OF BOND UNDER DYNAMIC LOADING. Atis A. Liepins. Sept. 1959. 101p. (AECU-4563)
A program to determine the bond strength of reinforced concrete under dynamic loading, to compare bond strengths under static and dynamic loading, and to test the adequacy of ACI Building Code is described. The tests showed that local static bond strengths may be as high as 0.75 f'_c and that under dynamic loading this strength increases to f'_c. For all practical lengths of embedment of bars, steel failure may be expected under both static and dynamic conditions.

107
BEHAVIOR OF WALL PANELS UNDER STATIC AND DYNAMIC LOADS. John M. Cord. Aug. 1952. (AFSWP-111)
Experimental techniques, results, and conclusions are presented from a series of laboratory tests on the following wall panel materials subjected to transverse bending by both static and dynamic loads: brick masonry, asbestos cement board, and metal siding sheets. Results indicate that brick panels sustain ultimate strains and deflections 20 to 50% greater under dynamic loading than under static loading. Asbestos cement panels were observed to sustain ultimate strains and deflections 3 to 20% greater under dynamic loading than under static loading. Metal siding panels were observed to sustain yield strains and deflections 0 to 17% greater under dynamic loading than under static loading.

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108
PROCEDURES AND SPECIFICATIONS FOR EXPERIMENTAL DETERMINATION OF LOAD-DEFLECTION CHARACTERISTICS OF FULL-SCALE BUILDINGS. Donald A. DaDeppo. (In cooperation with the Air Force Special Weapons Center, Air Research and Development Command, Kirtland Air Force Base, New Mexico.) April 1958. (AFSWC-TR-57-32; AD-157-167)
Procedures are outlined for conducting static and dynamic tests on full-scale structures. Buildings which were considered for testing were of steel or reinforced concrete construction, and were either single-story industrial structures or in the range of from 3 to 5 stories. The report includes specifications covering the selection, inspection, and modification of test structures; discussion of vibration, shock, pulldown, and story shear tests; and description of methods of loading, instrumentation, and recording. Estimated costs for the various major items of required test equipment for the static and dynamic tests are tabulated in an appendix.

109
THE DIFFRACTION OF SHOCK WAVES THROUGH OBSTACLES WITH VARIOUS OPENINGS IN THEIR FRONT AND BACK SURFACES. Russell E. Duff and Robert N. Hollyer, Jr. Nov. 7, 1950. 56p. (NP-1886)
Results are presented of a photographic investigation of shock-wave diffraction through models with various openings in their front and back surfaces. Also included is a discussion of a method for determining the strength of shock waves by measurements of limiting Mach configurations. Three symmetric models were used in this investigation. The outside dimensions of each were 1-½" × 4-½".

110
DAMAGE TO COMMERCIAL AND INDUSTRIAL BUILDINGS EXPOSED TO NUCLEAR EFFECTS. Bruce G. Johnston. (In cooperation of the Office of Civil Defense Mobilization, Battle Creek, Michigan) PROJECT 31.2 [OF] OPERATION TEAPOT. Final Report. Feb. 1956. 107p. (WT-1189)
One equipment control building designed to be blast resistant and two each of three types of utility buildings were exposed to the effects of a nuclear detonation. One utility building was frameless, with deeply corrugated wall and roof sections; a second was largely frameless, utilizing interlocking channel sections; and in the third the aluminum-panel wall and roof covering was supported by steel frames. The equipment control building utilized continuous-welded steel frames and reinforced-gypsum curtain-wall construction. The utility buildings were exposed to over-pressures of ~0.7, 3.0, and 1.3 psi, and the control building was exposed to ~4.1 psi. The equipment control building was not structurally damaged by the blast. Each of the three utility buildings received severe damage at the near range. At the far range the damage in every case was repairable. The test results are discussed, and recommendations for improved designs are made. Some damage records are correlated by means of dynamic analyses with pressure-time data and studies of structural resistance.

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111
INFLUENCE OF GRADE OF STEEL ON BLAST RESISTANCE OF REINFORCED CONCRETE BEAMS. Final Report. W. A. Shaw and J. R. Allgood. Jan. 1, 1959. 23p. (AD-201109; NY 340 030-11)
A method for comparing different grades of steel as reinforcement in concrete beams subjected to blast loads is presented. It is shown that whether one type of steel is better than another depends primarily upon the criterion of failure selected, the characteristics of the loading, and the amount of steel used. Results are listed, and conclusions are given.

112
PROGRESS IN RADIATION SHIELDING RESEARCH FOR

SHELTERS. Technical Note N-385. A. B. Chilton. June 23, 1960. 62p. (NP-9023)

The present status of radiation shielding technology is reviewed, with particular emphasis on protection against radiation resulting from nuclear weapon explosions. The exposition described the basic concepts and presents brief descriptions of important research work carried out in various institutions in this country during the past decade. An extensive list of source material is provided.

112a

DESIGN CHARTS FOR R/C BEAMS SUBJECTED TO BLAST LOADS. Technical Report R-121. J. R. Allgood and G. R. Swihart. Oct. 19, 1960. 138p. (NP-9922)

An ultimate load theory is combined with an idealized dynamic theory to form a computational program for the development of a set of design charts for reinforced concrete beams. The behavior of beams under blast loading is reviewed to aid in the explanation of the computational program and the charts. A procedure of the treatment of shear and bond is presented; the design curves are given and exemplified; and their limitations are discussed.

Naval Material Laboratory, Brooklyn, New York

113

RESEARCH REPORT ON THE PROTECTION AFFORDED BY WINDOW SCREEN MATERIALS AGAINST INTERNAL THERMAL RADIATION. Lab. Project 5046-3, Part 95, Final Report. L. Banet and A. Hirschman. June 8, 1956. 18p. (AFSWP-952)

The degree of protection offered by various window materials (glass, aluminum sheet, aluminum screening, and aluminum venetian blinds) was investigated. For this purpose eight thermal paper indicators were selected, calibrated and evaluated after nuclear bomb exposure, with and without screen materials. In addition, the "protection factor" was determined independently by spectrophotometric means. Since results of two methods agree, it is possible to evaluate protection of screens by transmittance measurements.

Naval Radiological Defense Laboratory, San Francisco, California

114

CONTAMINATION-DECONTAMINATION CHARACTERISTICS OF FOUR COMMON BUILDING MATERIALS; INTERIM REPORT, by John Howell and V. V. Vandivert. Oct. 10, 1951. Decl. Feb. 3, 1959. 49p. (AD-330(T))

Relative determinations were made of the contamination-decontamination characteristics of 4 building materials (concrete, soft wood, brick, and stucco) contaminated under conditions simulating those of an underwater atomic-bomb detonation. A sea-water solution containing Y^{91}, Sr^{89}, Sr^{90}, Zr^{95}, and Nb^{95} was used as the contaminating spray. Radioactivity measurements (by counting and radioautographic techniques) were made before and after decontamination; corrections were made for background and geometry but not for backscattering or reflection effects. Liquid cleaning methods (salt water, complexing agent, caustic and steam cleaning) were employed in the decontaminating procedures as well as dry surface-removal techniques (vacuum blasting, sanding, wood planing, and wire brushing). Contaminability of the building materials was determined to be a function of surface characteristics. The contaminability of the unweathered standard-paint surfaces was independent of the underlying material, except in the case of extremely rough surfaces. Coating materials appeared promising as a means of protecting surfaces from fission-product contaminants in solution. Highly contaminable materials were difficult to decontaminate, while materials highly resistant to contamination were generally easy. Dry decontamination methods were effective but presented problems of waste control and disposal. Liquid decontamination methods were adequate on painted surfaces.

115

This abstract is intentionally omitted.

116

CONTAMINABILITY OF SELECTED MATERIALS—LIQUID HOLD-UP AS A MEASURE OF THEIR CONTAMINABILITY. L. H. Gevantham, B. Singer, T. H. Shirasawa, and H. K. Chan. June 7, 1954. Decl. Feb. 4, 1959. 70p. (USNRDL-TR-11)

Measurements were made of the relative contaminability of selected materials from liquid fall-out by relating their contaminability to the liquid hold-up of their surfaces. Their contaminability when subjected to either a saturating rain or a base surge is determined for two extreme orientative positions—vertical and horizontal. The parameters affecting liquid hold-up on surfaces are discussed. For the saturating rain condition, the surfaces contaminate to approximately the same degree when horizontal. The greatest variation is observed when materials are vertical. In decreasing order of contaminability from saturating rain, they are: porous materials, wood, roofing, asphaltic emulsion, metals, rubber, plastics, paints and varnishes. Liquid hold-up differs little between horizontal and vertical surfaces exposed to the base surge condition. In decreasing order of contaminability from the base surge, they are: porous surfaces, paints, plastics and asphaltics, metals, wood, roofing, galvanized iron, and glass. The data are extended to examine materials in a target complex exposed either to a deep underwater or a harbor burst. A practical examination of the gamma radiation level which would be present on the horizontal and vertical surfaces of three naval vessels is also given.

117

DECONTAMINABILITY OF SELECTED MATERIALS: DECONTAMINATION BY SPRAYING WITH AND IMMERSION IN LIQUID. L. H. Gevantman, J. F. Pestaner, B. Singer, and D. Sam. Aug. 31, 1954. Decl. February 4, 1959. 69p. (USNRDL-TR-13)

Results are presented of a study of radioactive contamination and decontamination of construction materials. Decontaminability is measured by the reduction in level of a definite deposit of radioactivity on a material being washed by either spraying or immersion in water. The results, expressed as ratios of residual to initial activity are analyzed statistically. Data are included on the following materials: paint surfaces, brass, galvanized iron, stainless steel, aluminum, plastic (Plexiglass), tar and gravel, asphalt-emulsion, roll roofing, concrete, brick, asbestos siding, and wood. The data show that spray washing is superior to immersion for reducing the activity level. Paint surfaces do not differ appreciably in decontaminability. It is confirmed that impervious materials decontaminate to lower levels than porous materials.

118

THERMAL VULNERABILITY OF MILITARY INSTALLATIONS. A. Broido and C. Trilling. Aug. 11, 1955. 99p. (USNRDL-TR-101; AFSWP-911)

In the event of an atomic attack, fire damage as a result of thermal radiation may extend well beyond the region of serious blast effects. The probability of producing disastrous fires in a military installation is dependent to a large extent upon the condition of the base and its environs at the time of attack. Moreover, certain practices which, from a conventional fire prevention point of view, were considered acceptable or even desirable may serve to increase the probability of thermal damage. Following a survey of about 100 typical military installations, this study attempts a realistic evaluation of the characteristics of existing military installations which make these installations vulnerable to the thermal effects of atomic weapons. Factors influencing fire initiation, fire spread, and fire suppression are considered. Realistic changes in philosophy as well as in construction of present and future installations are discussed.

119

PERFORMANCE SPECIFICATIONS FOR A SOUND NATIONAL SHELTER SYSTEM. W. E. Strope. Feb. 13, 1957. 34p. (USNRDL-TR-132)

The urgent need for a national shelter program because of advance of megaton weapons is pointed out. Conclusions are based on five years of military atomic defense studies and include shelter performance specifications and cost estimation for a sound and feasible national shelter program. Three classes of shelter which would provide adequate protection to the nation's population are described. Interior arrangement and equipment of a typical shelter are illustrated. Estimated shelter construction costs per person range from about $300 depending on shelter class, resulting in an estimated total construction cost for the national shelter system of about $15 to 20 billion. Additional costs for the total program would include those for development and engineering, land acquisition, and shelter equipment.

120

THERMAL RADIATION DAMAGE TO CELLULOSIC MATERIALS. PART II. IGNITION OF ALPHA CELLULOSE BY SQUARE-WAVE EXPOSURE. C. P. Butler, S. B. Martin, and W. Lai. Nov. 26, 1956. 93p. Project NS 081-001. (USNRDL-TR-135; AFSWP-906)

The ignition behavior of blackened alpha-cellulose when exposed to square-wave inputs of radiant thermal energy is detailed for a wide range of irradiance levels and exposure times (0.4 to 25 $cal/cm^2/sec$ and 0.1 to 100 sec exposure). The material studied, chosen to represent a model "kindling fuel," was pure alpha-cellulose blackened by the addition of 2-½ percent carbon black by weight to the pulp and was produced in two densities and a range of thicknesses (0.55 g/cm^3 nominal density in 7 thicknesses from 0.004 in. to 0.030 in. and 0.73 g/cm^3 nominal density in 8 thicknesses from 0.002 in. to 0.030 in.). The data resulting are correlated to a single ignition behavior pattern using grouped parameters derived from considerations of diffusion of heat. Information is also included on the ignition behavior of newspaper and cotton sateen. Physical significance of the shape of the ignition behavior curve is discussed in terms of temperature attainment and subsequent pyrolytic processes, as follows: (1) Transition from flaming ignition to glowing ignition occurs at a value of the exposure time modulus $\sqrt{at_s}/L$ of about 1.5. (2) Spontaneous flaming ignition is identified with a given surface temperature rise and is independent of the thickness of the material over most of the range of exposure time modulus for which it occurs. (3) Sustained flaming ignition, a complex function of material thickness, diverges from spontaneous ignition at $\sqrt{at_s}/L = 0.8$ and appears to level off at a value of the incomplete energy modulus of about 1200 to 1300 for $\sqrt{at_s}/L < 0.4$.

121

FEASIBILITY AND APPLICABILITY OF ROOF WASHDOWN SYSTEM. W. S. Kehrer and M. B. Hawkins. May 7, 1958. 51p. (USNRDL-TR-232)

The feasibility and applicability of a washdown or water curtain system against radioactive fallout for building roofs were evaluated, based on the results of a water requirements experiment plus presently available information. The system was found to be both feasible and applicable. The initial coverage and minimum flow rates for 95 and 99% surface coverage were determined experimentally for aluminum roofing, masonite and composition roll roofing. The feasibility and applicability of the roof washdown system and discussed in terms of the basic design, comparative cost and effectiveness, water requirements, dependability of the system, and the type and size of buildings on which is applicable. The basic design of a roof washdown is described as consisting of a (1) water distribution system, (2) storage and filtration system, (3) water return system, and (4) roof surface system.

122

AN EXPLORATORY STUDY OF PROTECTION AGAINST NUCLEAR THERMAL RADIATION WITH SMOKING AND INTUMESCENT PAINTS. W. E. Shelberg and S. B. Martin. June 2, 1958. 43p. (USNRDL-TR-241)

An exploratory laboratory investigation was made on protection against nuclear thermal radiation with thermoshielding and intumescent paints. Thermoshielding paint, a new invention, protects by interposing a rapidly produced, self-generated smoke screen between substrate and radiation. Intumescent paint, commercially available, protects by expanding into a heat-insulating, sponge-like mat. Three experimental, prototype thermoshielding paints were invented, and one intumescent paint, Albi-99, was selected for study. The former consisted of Navy gray paint having tetracene (i.e., 1-guanyl-4-nitrosoaminoguanyltetrazene), nitrosoguanidine or sebacic acid as smoke-generating components. The paints were applied on thin, ¾-in. diameter, primered copper discs. These were subjected to square-wave and simulated weapon pulse exposures with the Mitchell thermal radiation source, and curves of temperature rise versus time after incidence were determined. Degree of protection was evaluated relative to ordinary Navy gray paint, and was expressed numerically for any particular time after incidence as a percentage $(A-B)/(A) \times 100$, where A represents the temperature rise of the Navy gray paint disc, and B that of the test paint disc. The degree of protection varied with paint and exposure characteristics. The thermoshielding sebacic acid paint protected appreciably (7 to 18%) throughout a range of simulated weapon exposures extending from one of high peak irradiance and moderate yield (22 $cal/cm^2/sec$ and 0.2 Mt) to one of low peak irradiance and high yield (5 $cal/cm^2/sec$ and 10 Mt). The explosively decrepitating thermoshielding paints, tetracene and nitrosoguanidine, protected appreciably (13 to 19%) when the simulated weapon pulses delivered the majority of the radiation within a few seconds, but they failed to protect when the majority was delivered during a period of many seconds. Intumescent Albi-99 protected appreciably (7 to 23%) when temperature rises were great enough (about 225 to 250°C) for formation of its relatively slowly produced foam blanket, but it failed completely for large, vary rapid temperature rises since immediate decomposition then caused loss of the intumescent property. All paints showed appreciable, sustained protection at exposures corresponding to 22 cal/cm^2/sec peak irradiance and 1-Mt yield: sebacic acid paint, 14%; tetracene and nitrosoguanidine paints, 19%; Albi-99 paint, 23%.

123
STATUS OF RADIOLOGICALLY PROTECTIVE COATINGS FOR LAND TARGET SURFACES. W. L. Owen. Nov. 13, 1958. 54p. (USNRDL-TR-277)
The results of five field tests have been reviewed to ascertain the contribution of protective coatings toward improving the contamination-decontamination characteristics of standard building material. Decontamination effectiveness values are presented for several procedures used in the removal of dry, slurry and wet contaminants. The increase in effectiveness due to the presence of protective coatings is then measured, and those coatings which contributed significantly are noted. Criteria are defined which will govern the future development of more effective coatings.

124
SPECIFICATIONS AND COST OF A STANDARDIZED SERIES OF FALLOUT SHELTERS. W. E. Strope, L. G. Porteous, and A. L. Greig. Oct. 6, 1959. 136p. (USNRDL-TR-366)
Basic performance specifications are developed to govern the design of personnel shelters to provide protection against radioactive fall-out. Consideration is also given to protection against blast, heat, and fires. Design specifications and cost estimates are prepared for a shelter based on a 25 ft by 48 ft ammunition storage magazine. Provision is made for 14-day occupancy by 100 people. The cost differentials of various choices of performance characteristics are estimated. The design is in sufficient detail to permit construction. Shelters of this type may have wide application in residential areas, industrial plants, and military installations.

125
EVALUATION OF COUNTERMEASURES SYSTEM COMPONENTS AND OPERATIONAL PROCEDURES. W. E. Strope. Aug. 14, 1958. 159p. Project 32.3 of OPERATION PLUMBBOB. (WT-1464)
Tests were conducted during Bursts Diablo and Shasta in order to evaluate some operational characteristics of a radiological shelter and to determine values for some countermeasures-system parameters. The project consisted of two phases, the first involving measurements made by project personnel in a manned station having the characteristics of a high-performance radiological shelter and the second involving monitoring and reclamation operations in an area near the shelter beginning about 1 hr after burst. Measurements were made inside the shelter beginning at shot time to (1) test a simple shelter monitoring system, (2) test a proposed ventilation intake configuration intended to eliminate a requirement for filtration of the shelter air supply, (3) determine the effective gamma-radiation shielding afforded by an operational shelter, including two different exhaust ventilation configurations and a simple entrance configuration, and (4) determine those radiation and fallout characteristics needed to evaluate the operational measurements. The second phase involved (1) the test of a key-point initial monitoring technique, (2) the test of two proposed techniques for determining reclamation effectiveness in advance of reclamation operations, (3) the test of the feasibility of achieving a residual number of 0.01 in a cleared area, and (4) the test of a barrier as an alternative to a buffer zone. The shelter, having a minimum earth-cover thickness of 3 ft, provided an average shielding reduction factor of about 10,000. All openings in the earth cover for ventilation and other purposes were satisfactory from a radiological point of view with exception of the straight entrance way. The shelter monitoring system provided adequate information. The air-filter data showed no requirement for air filtration at air intake flow rates 300 to 600 cfm with the intake configuration used. All objectives in the second phase were successfully met with an exception. It was not possible to obtain an adequate test of the feasibility of achieving a residual number 0.01 in the staging area because of the poor condition of the test area.

Naval Research Laboratory, Washington, D. C.

126
DYNAMICS OF LINEAR ELASTIC STRUCTURES. [INTERIM REPORT]. Ralph E. Blake and Eloise S. Swick. Oct. 7, 1954. 27p. (NRL-4420)
The equations for the response of linear elastic structures to dynamic loading are derived by using only the mathematical methods familiar to most engineering graduates. The differential equations describing the response of a linear elastic structure subjected to a load are seen to be similar to the equation of a simple oscillator subjected to a similar load. Duhamel's Integral is applied to the problem in order to determine the response of linear elastic structures to various types of excitations. Responses are obtained for step and impulse type loadings as well as for general forces. A general equation is obtained for the response of a linear elastic structure to an applied force. This equation is further extended to account for a distributed force; that is, for a load which is distributed over a large area of the structure instead of being applied at a point of the structure. The response of an elastic structure to a shock motion of its foundation is developed. The expression for the stress at a point is derived and it is seen that the shock spectrum is the best available measure of the severity of a shock because the shock spectrum shows the effect of the shock motion on the stress.

127
FALLOUT PROTECTION AFFORDED BY STANDARD ENLISTED MEN'S BARRACKS. C. W. Malich and L. A. Beach. Jan. 7, 1957. 23p. (NRL-4886)
The shielding properties of standard Navy enlisted men's barracks have been calculated for the gamma radiation associated with fallout from nuclear weapons. Potential improvements in shielding have been investigated. The major benefit of present barracks is the possibility of the prevention of deposition of radioactive material on personnel, if doors and windows are kept closed during fallout. In addition, the gamma-ray dose is reduced about one half inside the building by keeping the radioactivity outside, and the shielding of the walls gives a further reduction in dose

of a factor of two. There is no large variation in average dose throughout most of the building. Most of the radiation is transmitted through the doors and windows. Improvements in shielding are incompatible with economy and with pleasant routine living. An enlarged, properly designed basement is suggested for emergency quarters.

128
RADIATION PROTECTION AFFORDED BY BARRACKS AND UNDERGROUND SHELTERS. C. W. Malich and L. A. Beach. Aug. 22, 1957. 48p. (NRL-5017)

The shielding properties of standard Navy enlisted men's barracks and underground shelters have been calculated for the gamma radiation associated with fall-out from nuclear weapons. Also the attenuation of prompt radiation from nuclear weapons into underground structures was studied. The major benefit of present barracks is the possibility of the prevention of deposition of radioactive material on personnel. In addition, by gamma-ray dose is reduced about one-half inside the building by keeping the radioactivity outside, and the shielding of the walls gives a further reduction in dose of a factor of two. Excellent protection against fall-out radiations can be provided by underground shelters if entrances and vents are properly designed to minimize leakage. Attenuations of fall-out radiation by underground shelters range from 10^{-4} at 3 ft of minimum thickness of earth cover to 10^{-10} at 10 ft of earth cover. Attenuations of prompt radiation by underground shelters are less, due to more penetrating components, but still provide adequate protection against many attack situations. Attenuations range from 10^{-2} at 3 ft of cover to 10^{-6} at 10 ft of cover.

129
EFFECT UPON SHOCK SPECTRA OF THE DYNAMIC REACTION OF STRUCTURES. George J. O'Hara. Dec. 16, 1958. 19p. (NRL-5236)

Attempts to use fiducial limit curves of a set of classes of shock spectra as a basis for the design of structures have shown that the design spectra obtained by the combinatorial analysis of many shock spectra tend to be overconservative. This interim report presents a possible explanation for this. It exhibits some experimental evidence to show that the values of interest in a shock spectrum plot tend to lie in the valleys of that plot and not upon the peaks, whereas fiducial limit curves are controlled by the peaks of the individual shock spectra.

New York Operations Office, Health and Safety Laboratory, AEC

130
FALLOUT COUNTERMEASURES FOR AEC FACILITIES. Preliminary Report. Alfred J. Breslin and Leonard R. Solon. Dec. 1955. 66p. (NYO-4682)-A

Results are presented from a preliminary evaluation of possible measures which may be applied to afford protection to personnel and to render a facility inhabitable from the point of view of conducting normal functions following exposure to a potentially lethal fall-out event. Theoretical relationships were derived to demonstrate the feasibility of estimating the protection against γ radiation afforded by conventional structures. Methods are suggested by which the inherent protection may be increased. Criteria are suggested from which may be determined the time after a bomb detonation when recovery operations may be begun safely. It was concluded that practical countermeasures capable of providing adequate protection and enabling the prompt reactivation of plant functions are feasible.

131
RADIATION PROTECTION WITHIN A STANDARD HOUSING STRUCTURE. Robert T. Graveson. Nov. 1956. 13p. (NYO-4714)

A one story building was the subject of a radiation survey, subsequent to fall-out contamination of the surrounding area. The thin aluminum walls of the building offered no significant shielding. However, the gamma radiation reading at the center of the building on the uncontaminated surface, under the roof cover effectively reduced the γ-dose rate at the center of the building by a factor of 10 compared to the open field readings. The distribution of dose rate measured from 1 to 7 feet above the floor surface, indicated areas within the building, close to the floor, where the dose rate was considerably reduced.

Nuclear Shielding Supplies and Service, Incorporated, White Plains, New York

132
RADIATION SHIELDING—BIBLIOGRAPHY. 1959. 27p. (NP-8312)

A literature search of 331 references on shielding is presented.

Oak Ridge National Laboratory, Oak Ridge, Tennessee

133
EXPERIMENTAL EVALUATION OF THE RADIATION PROTECTION AFFORDED BY RESIDENTIAL STRUCTURES AGAINST DISTRIBUTED SOURCES. J. A. Auxier, J. O. Buchanan, C. M. Eisenhaur, and H. E. Menker. (In cooperation with the Division of Biology and Medicine, AEC.) Sept. 1958. 133p. (CEX-58-1)

A study was made to obtain information that could be used to evaluate the protection afforded by residences against radiation due to fall-out. The sources used were Co^{60} and Cs^{137}, and the radiation dosimeters used were pocket type ionization chambers. Measurements were made for distributed sources (400 Co^{60} and 20 Cs^{137}) and for single sources located inside the structures (one each, 2-curie Co^{60} and Cs^{137}). Attenuation measurements were made for five houses of typical domestic design and construction. Several modifications were made to the houses, and the attenuation measurements were repeated. The houses, located at the Nevada Test Site, included single- and two-story houses with and without basements and with light and heavy walls. For comparison with the house data the dose-rate distribution above an extended plane source was measured in a "phantom" house, i.e., air measurements with the instrument fixed on a framework of thin-walled aluminum tubing. Although the complete analysis of the data is not yet available, some typical analyses are presented, and the effectiveness of some of the modifications is illustrated.

134
EXPERIMENTAL EVALUATION OF THE RADIATION PROTECTION AFFORDED BY TYPICAL OAK RIDGE

HOMES AGAINST DISTRIBUTED SOURCES. T. D. Strickler and J. A. Auxier. Jan. 1960. 51p. (CEX-59.13)

The protection afforded against simulated fallout radiation has been evaluated for several typical homes in the Oak Ridge area. Nine houses were chosen to represent a variety of construction materials, topographical conditions, and sizes; they included three types of Oak Ridge Cemesto houses, one concrete-block house with a basement "fallout shelter," and two wood-frame houses. The protection factor (ratio of open-field exposure dose rate to exposure dose rate in the house) in all these houses ranged from 2 to 5 on the main floor and from 5 to 30 in the basements, except in the fallout shelter, where the protection factor was greater than 100. The analysis showed that sloping lots, common to Oak Ridge, do not appreciably affect the protection factor for the main floor. Owing to the generally increased exposure of the basement walls on such lots, the protection factors in the basements were typically lower than in similar basements built on level lots.

Office of Civil and Defense Mobilization, Battle Creek, Michigan

135

DAMAGE TO CONVENTIONAL AND SPECIAL TYPES OF RESIDENCES EXPOSED TO NUCLEAR EFFECTS. Philip A. Randall. In cooperation with the Housing and Home Finance Agency, Washington, D. C. PROJECT 31.1 [OF] OPERATION TEAPOT-PRELIMINARY REPORT. May 1955. 58p. (ITR-1194)

Ten residential structures of wood, brick, lightweight reinforced concrete block, and lightweight precast concrete slabs were exposed to the effects of Apple Burst II. Each type of house was tested in a pair; one house at an anticipated overpressure at which collapsed or major damage might be expected; the other house, its counterpart, at an anticipated overpressure at which damage without collapse might be expected. Of the ten houses included in the test, the condition of seven was such that they could be made habitable for emergency occupancy by shoring and repairs. In practically all of the houses the windows and exterior doors were destroyed. In all except the two collapsed houses, the greatest danger to the occupants would appear to have been from missiles of glass, venetian blinds, furniture, and other fragments.

136

EVALUATION OF FCDA FAMILY SHELTER, MARK I, FOR PROTECTION AGAINST NUCLEAR WEAPONS. Neal Fitzsimons. PROJECT 30.3 [OF] OPERATION PLUMBBOB-PRELIMINARY REPORT. Aug. 1957. 27p. (ITR-1450)

An underground reinforced-concrete family shelter designed for six persons was tested at three anticipated nuclear blast overpressures: 30, 48, and 65 psi. Assuming static-load equivalents and following the procedures recommended in the appendix to ACI-56, "Ultimate Strength Design," the structures were calculated to sustain a 30-psi long-duration overpressure. Postshot examination of all shelters indicated there was little or no deflection in the reinforced-concrete members. Although the actual blast load was of short duration, the natural period for the structure was also short, therefore it is felt that the structures would withstand similar overpressures from long-duration blast loadings. The average attenuation factor for gamma radiation varied from 3000 to 4500. Permanent damage was confined to the exposed portions of the ventilation pipes, which were bent to a nearly horizontal position. The steel-plate door at the 65-psi level was dished inward about 1¼ in., but it opened and closed easily.

137

EVALUATION OF INDUSTRIAL DOORS SUBJECTED TO BLAST LOADING. Neal Fitzsimons. PROJECT 31.4 [OF] OPERATION PLUMBBOB—Preliminary Report. Feb. 1958. 27p. (ITR-1459)

Five types of industrial doors were designed and tested under blast effects of a nuclear device at the Nevada Test Site. Two groups of doors were tested, one group at 3½ psi and the other at 7 psi peak incident overpressure. Maximum deflections were measured on all doors, and the deflection-time relation was determined for a steel-plate door located at the 7-psi range. The five basic types of doors tested were steel plate, cellular steel, wood plank, hollow plywood, and solid plywood. The results of the test indicated that low-silhouette industrial and commercial buildings located in a 7-psi peak incident overpressure range can be provided with inexpensive doors that will afford protection from blast effects of nuclear weapons.

138

TEST AND EVALUSTION OF ANTIBLAST VALVES FOR PROTECTIVE VENTILATING SYSTEMS. F. C. Allen, A. M. Hatch, D. E. Keyt, and D. P. Rohrer. PROJECT 31.5 OF OPERATION PLUMBBOB—PRELIMINARY REPORT. Aug. 1958. 42p. (ITR-1460)

Tests were made to determine the operating characteristics and effectiveness of prototype antiblast valves under actual conditions of nuclear blast. Four 24- and five 16-in. valves designed to operate with overpressures up to 50 psi and two 12-in. valves designed to operate with overpressures up to 100 psi were tested. The valves were mounted to simulate shelter protection service and exposed to side-on blast pressures as follows: one of each size at the 7½-psi range, a 16- and a 24-in. valve at the 50-psi range, a 12-in. valve at the 100-psi range, two 16- and one 24-in. at the 7-psi range, and one 16- and one 24-in. at the 3½-psi range. One of the 16-in. valves at the 7-psi range had a pneumatic attachment triggered by the light flash from the fireball which closed the valve before the arrival of the shock wave. All pressure-sensitive valves closed upon arrival of the shock and reopened after the pressure had subsided. The thermal-triggered valve closed in advance of the shock-wave arrival and remained closed for the period of the test.

139

RETEST AND EVALUATION OF ANTIBLAST VALVES. James E. Roemke. PROJECT 70.3 [OF] OPERATION HARDTACK, PHASE II, PRELIMINARY REPORT. Oct. 1958. 23p. (ITR-1717)

Three antiblast valves, one each of the 12-, 16-, and 24-in. sizes, were tested at maximum predicted 175-, 150-, and 125-psi overpressure ranges from a very small yield device. The valves were mounted vertically on cover slabs of underground pipe cells. They were instrumented to obtain: (1) pressure-time measurements inside the weather-proof hood; (2) pressure-time measurements in the pipe expansion chamber; and (3) position-time measurements of each valve disk. The 12- and the 16-in. valves closed upon arrival of the shock wave and reopened after the pressure had subsided. The 24-in. valve, which had a larger mass of moving parts, only partially closed. Since this was an extremely short duration device, it appears that the pressure wave had subsided prior to overcoming the inertia of the larger valve. Peak pressures inside the valve hoods were somewhat less than the measured peak incident over-pressure valve which was approximately 20 psi. Peak pressures in the pipe test cells were less than 2 psi. Data from this test will be evaluated and correlated with data from Operation Plumbbob to obtain the best over-all information for refinement of design.

140

EFFECT OF NUCLEAR WEAPONS ON OCDM FAMILY FALLOUT SHELTER. James E. Roembke. PROJECT 70.4 [OF] OPERATION HARDTACK, PHASE II, PRELIMINARY REPORT. Oct. 1958. 35p. (ITR-1718)

Underground reinforced-concrete family fall-out shelters designed for 4 to 6 persons were located to receive anticipated overpressures of 5, 10, and 20 psi from Vesta Burst. Postshot examination of the shelters indicated there was no apparent structural damage. Preliminary blast reports indicate that overpressures were less than anticipated and of much shorter duration than expected. The change in values resulted from a rescheduling of devices after the shelters had been constructed. The device used for the test did not have the same characteristics as the original device. Fall-out contours are given for Vesta Burst. The shelters were instrumented for radiation attenuation measurements. These data will be analyzed and evaluated in the final report.

141

BLAST EFFECTS OF ATOMIC WEAPONS UPON CURTAIN WALLS AND PARTITIONS OF MASONRY AND OTHER MATERIALS. Benjamin C. Taylor. PROJECT 3.29 [OF] OPERATION UPSHOT-KNOTHOLE—PRELIMINARY REPORT. June 1953. Decl. Feb. 4, 1958. 29p. (UKP-32)

Tests were made of a number of conventional types of curtain walls and interior partitions at two pressure levels, by exposing them in reinforced concrete cellular supports, to determine their relative effectiveness in resisting blast pressures. The curtain walls were photographed during the test at 64 frames per second and numerous curtain walls were instrumented for displacement-time records. The extent of damage and the photographic and instrument records appear satisfactory for good interpretation of results when these records are available for study and analysis. A few simple conclusions which appear obvious from the damage pattern have been drawn, with respect to relative strength of windowed and solid curtain walls, failure of partitions behind windowed curtain walls, and the debris hazard from curtain walls and partitions.

142

EXPOSURE OF MOBILE HOMES AND EMERGENCY VEHICLES TO NUCLEAR EXPLOSIONS. Ebe R. Shaw and Frank P. McNea. PROJECTS 36.1 and 36.2 [OF] OPERATION TEAPOT. July 1957. 53p. (WT-1181)

Experiments were conducted during Operation Teapot to determine the effects of a nuclear explosion on mobile homes at pressure levels which might be expected in the suburbs of a large city and to determine the effects on emergency vehicles and their equipment located at various simulated distances from near Ground Zero to the suburbs of a large city. Missiles produced by flying glass and the translocation of furniture in the mobile homes are potential hazards to personnel occupying these homes at the time of the blast. Screening or other means of protecting the interior against glass splinters reduces this hazard. By rearrangement of the displaced furniture, clearing up debris, and improvising window coverings, trailers in this area of damage could readily be made habitable. Emergency vehicles caught in the open near Ground Zero would be completely destroyed. Vehicles in medium- and low-pressure regions would suffer damage, but the vehicles and equipment would probably be operable.

143

EVALUATION OF VARIOUS TYPES OF PERSONNEL SHELTERS EXPOSED TO AN ATOMIC EXPLOSION. L. J. Vortman. (In cooperation with the Federal Civil Defense Administration, Battle Creek, Mich.) May 1956. 122p. Projects 34.1 and 34.3 of OPERATION TEAPOT. (WT-1218)

Underground shelters (50-man capacity) were exposed to nuclear explosions; two of these shelters were exposed at 1050 ft. Three basement exit shelters were exposed at 1350 ft.; two were exposed at 1270 ft. and two at 1470 ft. Groups of three aboveground utility type shelters, one of masonary blocks, one of precast reinforcement concrete, and one of poured-in-place reinforced concrete, were exposed at 2250, 2750, and 3750 ft. Reinforced-concrete bathroom shelters were placed in rambler type houses at 2700 and 10,500 ft. from the burst. Three types of basement shelters were constructed in two frame houses at 5500 and 7800 ft., and two types of basement shelters were constructed in two brick houses at 4700 and 10,500 ft. from the same burst. On neither exposures was structural damage sustained by the large underground personnel shelters. Occupants of the closed shelter would not have been disturbed by blast debris, or radiation. Damage to the basement exit shelters was inversely proportional to their distance from ground zero and was directly proportional to the amount of opening in the entrance. The closed shelter at the greatest distance received the least damage but was not satisfactory as a personnel shelter at the lowest pressure tested. Utility shelters provided unsatisfactory protection from radiation. All indoor family type shelters were satisfactory as tested and would have provided adequate protection for occupants.

144

PENETRATION INTO CONCRETE OF GAMMA RADIATION FROM FALLOUT. W. F. Titus. Apr. 27, 1960. 26p. Project 35.1 of OPERATION PLUMBBOB. (WT-1477)

The penetration into concrete of gamma radiation from fallout has been measured in an idealized geometry as a function of time after the detonation of a nuclear device. At the same time, the exposure dose rate in air at heights of 3 and 9 ft above the ground was measured with two detectors suspended from a tower and shielded from above with lead so as to be sensitive primarily to radiation from fallout on the ground. For this test a "sandwich" made of seven concrete slabs, forming a mass of concrete with face dimensions large enough to reduce edge effects to a negligible amount, was buried with its top surface flush with the ground. Remote-reading detectors were placed between the concrete slabs, thus permitting measurements of dose rate as a function of depth in concrete. The concrete mass and the tower were located in the center of a cleared and leveled area approximately 200 yd in diameter. Thus the gamma radiation at the detectors originated from an essentially infinite-plane source of radiation. Results are presented both as a function of time after detonation and of depth of penetration of the radiation into concrete. A comparison of the results with theoretical calculations is made.

REFERENCES

Office of the Chief of Engineers. Protective Construction Branch, Washington, D. C.

145
FINAL REPORT, SUPPLEMENT SKEW STRUCTURES PROGRAM (UNDERGROUND EXPLOSION TESTS) N. M. Newmark, C. H. Norris. June 1953. 21p. (AFSWP-126)

Tests were conducted in order to determine the effect of varying angles of skew of the walls of underground structures on the damage to such structures produced by underground explosions. Two charges were detonated in dry clay at 0.2 scale (2560 pounds of TNT) with a number of underground targets of two different types, namely: open boxes consisting only of four walls of reinforced concrete and closed boxes consisting of four walls of reinforced concrete walls with integrally cast floor and roof slabs. Results indicate that skew targets present a much more serious problem with regard to corners and joints than do normal targets. All underground targets should be particularly well reinforced and braced so as to avoid damage to the corners in the event of underground explosions occuring at oblique angles.

Office of Technical Information Extension Atomic Energy Commission, Oak Ridge, Tennessee

146
RADIATION SHIELDS AND SHIELDING. A BIBLIOGRAPHY OF UNCLASSIFIED AEC REPORT LITERATURE. Charles J. Engberg, comp. Sept. 1952. 30p. (TID-3032)

This bibliography contains 130 annotated references to unclassified reports on radiation shields and shielding. References are included to reports written prior to September 19, 1952. Author, subject, and report number indexes are included. (See also TID-3032(Suppl. 1), TID-3303, and TID-3547)

147
RADIATION SHIELDS AND SHIELDING. A BIBLIOGRAPHY OF UNCLASSIFIED REPORT LITERATURE. Hugh E. Voress, comp. Dec. 1, 1954. 16p. (TID-3032(Suppl. 1))

This bibliography contains 53 annotated references to unclassified reports on radiation shields and shielding. References are included to reports written prior to October 1, 1954. Author, subject, and report number indexes are included. (See also TID-3032, TID-3303, and TID-3547)

148
RADIATION SHIELDS AND SHIELDING. A BIBLIOGRAPHY OF UNCLASSIFIED REPORT LITERATURE. July 1956. 20p. (TID-3303)

This bibliography contains 77 annotated references to unclassified reports on radiation shields and shielding. References are included to reports written prior to November 1954. Author, subject, and report number indexes are included. (See also TID-3032, TID-3032(Suppl. 1), and TID-3547)

149
RADIATION SHIELDS AND SHIELDING. A Literature Search. Henry D. Raleigh, comp. Feb. 1960. 56p. (TID-3547)

A literature search, containing 659 references, was prepared to serve as a reference guide until the completion of a formal bibliography (TID-3303, Suppl. 1). References pertain chiefly to reactor shielding, but references on gamma and neutron attenuation, properties and effectiveness of shielding materials, biological shielding, shielding design and theory, etc., are also included. (See also TID-3032, TID-3032(Suppl. 1), and TID-3303)

Princeton University, New Jersey

149a
THE DIFFRACTION OF SHOCK WAVES AROUND OBSTACLES AND THE TRANSIENT LOADING OF STRUCTURES. Technical Report II-3. Walker Bleakney. March 16, 1950. 83p. (NP-1508)

The shock tube when combined with the interferometer is a convenient device for studying the diffraction of shock waves around obstacles. The experiment consists in taking one picture of the optical fringes before they are disturbed by the shock wave and a second picture of the disturbed fringes at the moment of interest. (See also NP-9918)

149b
THE DIFFRACTION OF SHOCK WAVES AROUND OBSTACLES AND THE RESULTING TRANSIENT LOADING OF STRUCTURES. Technical Report II-6. D. R. White, D. K. Weimer and Walker Bleakney. Aug. 1, 1950. 59p. (NP-9918)

This report describes a continuation of an investigation which uses a shock tube combined with an interferometer for studying the diffraction of shock waves around obstacles. The experiment consists in taking one picture of the optical fringes before they are disturbed by the shock wave and a second picture of the disturbed fringes at the moment of interest. (See also NP-1508)

149c
SHOCK LOADING OF RECTANGULAR STRUCTURES. Technical Report II-11. Jan. 10, 1952. 64p. (AFSWP-140)

The shock loading of two-dimensional rectangular blocks has been investigated as a function of length to height ratio, shock strength, and time after impact. A shock pressure ratio of about 1.95 was used for diffraction experiments on blocks having length: height = 1:8 (thin wall), 1:1, 3:1, and ∞:1 front and back (step up and step down). In addition, the 1:1 block was studied at shock strengths of 1.26, 1.48, 3.05, and 5.00. Pressure distributions are also given for these same strengths, and 1.12, for the step up and step down at times so early that signals from the corner have not yet reached a boundary, this case being designated the ∞:∞. A peaked shock having a pressure ratio of 1.48 has been obtained in the shock tube, and although the pressure drops only to about half of its maximum value, effects appear which are not predicted by straightforward modification of flat-top shock data. These include the rapid decrease of the average pressure on the front face to a value below the free stream pressure and the persistence of average pressure on the back above that corresponding to free air pressure.

149d
THE DIFFRACTION OF A SHOCK WAVE OVER A THREE-DIMENSIONAL OBJECT. Technical Report II-14. D. E. Brickl and Walker Bleakney. April 1953. (NP-9920)

The study of the diffraction of shock waves over obstacles and the measurement of pressure forces by the use of shock tube and interferometer have been extended to measurements involving three-dimensional objects. This report describes the method and gives some preliminary experimental data demonstrating some of the possibilities of the scheme.

149e
DIFFRACTION OF A SHOCK WAVE OVER A RECTANGULAR NOTCH. Technical Report II-15. Wesley R. Smith. Feb. 1954. 24p. (NP-9921)

The average pressure vs depth in a two dimensional notch were measured at increasing times after flow was initiated by means of shock waves. Shock strengths of $\varsigma = P_1/P_2 = 0.178$ and 0.754 and notch depth to width ratios of 2:1 and 4:1 were used.

Public Buildings Service, Washington, D. C.

150
COMPARISON OF RESPONSES OF STRUCTURAL SLABS TO STATIC AND ATOMIC BLAST LOADINGS. Walton C. Clark. (In cooperation with the Office of Civil and Defense Mobiliztion, Washington, D. C.) PROJECT 31.4 [OF] OPERATION TEAPOT-PRELIMINARY REPORT. May 1955. 34p. (ITR-1195)

The comparison slab test was planned to determine the relation between the static and peak blast loads that will produce the same response in structural slabs placed in a horizontal position. Three pits were constructed at locations from ground zero where the predicted pressures were approximately 1, 5, and 10 psi. In each pit there were three sets of slabs, each composed of a reinforced concrete, a cellular steel, and a structural steel slab. The strength of each set of slabs in each pit was varied in order to increase the probability that one set would respond as predicted. Nine of the slabs were made in duplicate. The duplicates were placed over the pits after removing some slabs that had been exposed to the blast. These nine beams were loaded statically. From these results comparisons have been made of the static and blast loads to produce the same deflections in duplicate slabs. Comparisons will also be made of the accuracy of several different methods of analysis now being used to predict deflections caused by atomic blast loads.

Radio Electronics and Television Manufacturers Association, Washington, D. C.

151
THE EFFECTS OF A NUCLEAR EXPLOSION ON COMMERCIAL COMMUNICATIONS EQUIPMENT. Raymond H. Williamson. (In cooperation with the office of Civil and Defense Mobilization, Washington, D. C.). PROJECT 35.2 [OF] OPERATION TEAPOT–PRELIMINARY REPORT. May 1955. 66p. (ITR-1193)

Atomic-blast exposure tests on commercial communications equipment were conducted uring Operation Teapot, Apple II shot. These tests were made to provide Civil Defense planners with data for qualitative predictions of the probable survival range, the extent of damage, and nature of repairs required to restore communication service after a blast. Approximately 150 widely diversified units of communications equipment (mainly electronic, but including sirens) were exposed, under the sponsorship of the Radio-Electronics-Television Manufacturers Association (RETMA), two siren manufacturers and the Federal Civil Defense Administration (FCDA). Exposed items were in or near groups of structures located at approximately 4700 and 10,500 ft from ground zero. Where possible, identical products were exposed at these two locations, so that one set of items would be subjected to moderately severe damage and the other set to light damage. Tests showed that commercial communications equipment was generally more resistant to nuclear explosion damage than the structures in and near which the products were exposed. Additions concerning communications equipment were proposed to supplement FCDA published statements concerning "Blast Damage from Nuclear Weapons of Larger Sizes."

Ramo-Wooldridge Corporation, Guided Missile Research Division, Los Angeles, California

152
ON THE SAFETY OF STRUCTURES AGAINST GROUND SHOCKS. Y. C. Fung. June 15, 1957. 16p. (NP-8089); (GM-TR-191)

Some formulas useful in the analysis and application of ground shock information with a view either to estimating the safety of an existing structure against ground shocks or to designing economically a supporting structure which will protect the main structure against ground shocks are reported.

RAND Corporation, Santa Monica, California

153
PROCEEDINGS OF THE SECOND PROTECTIVE CONSTRUCTION SYMPOSIUM (DEEP UNDERGROUND CONSTRUCTION). John J. O'Sullivan, comp. March 24–26, 1959. Vol. I, 410p.; Vol. II, 488p. (R-341(RAND)Vol. I and II)

This symposium stresses primarily the design and construction of underground facilities to resist the effects of nuclear weapons. The following papers were presented: "Why Go Deep Underground?", Herman Kahn; "Peacetime Criteria Versus Wartime Performance", John J. O'Sullivan; "Nuclear Burst Phenomena Pertinent to Deep Underground Structures", H. L. Brode; "Communications Vulnerability", J. B. Carne; "Protection of Communications and Electronic Systems", F. R. Eldridge; "Mines and Other Concepts", Robert B. Panero; "Spalling and Large Blasts", John S. Rinehart; "Design of Underground Openings for Protection", Wilbur I. Duvall; "Rock Stabilization Through Bolting", Edward Thomas; "Problems of Instrumentation in the Underground Area", L. M. Swift; "Developing a Piezo-Electric Stress Gage", W. E. Schmid; "Some Factors to Consider in Site Selection and Design of Underground Protective Structures", Thomas L. White; "Factors to be Understood in Site Selection", M. D. Kirkpatrick; "Engineering Experiences in Deep Underground Construction and Their Effect on Engineering Decisions", Walter S. Douglas; Geological Factors in Choosing Underground Sites", W. R. Judd; "Potential Application of Borehole Photography to Site Investigations", Robert H. Nesbitt; "Tunnel Damage from Nuclear Explosions", Sherwood Smith; "Effects of Earthquakes on Tunnels", C. M. Duke and D. J. Leeds; "Remarks on Analytical Methods for Protective Structural Design", N. M. Newmark; "Blast Vulnerability of Deep Underground Facilities As Affected by Access and Ventilation Openings", Edward Cohen; "Shock Wave Attenuation in Tunnels", H. L. Brode; "Antenna Hardening", Edward Cohen and Pasquale DiNapoli; "Introduction to Section on Utilities Design", Bradley A. Peavy; "The Interaction of Utilities", Jack W. Barrett and C. T. Tsitsera; "Available Heat Sinks for Protected Underground Installations", Bradley A. Peavy; "Utility Problems in Submarines and Their Relation to Underground Construction", Cdr. William H. Cross; "Comments on Electrical Power Supplies for Underground Shelters", John Huth; "Collective Protection Against Chemical, Biological and Radiological Warfare Agents", J. C. Letts; "The Cooling Problems of Chemical and Nuclear Power Plant Application to A Class of Large Shelters", W. R. Elswick; "Introduction to Session on New Construction Methods and Equipment", R. L. Loofbourow; "Adaptation of Oil Well Drilling Techniques", Gene Graham; "Recent Developments for Drilling Large Diameter Holes", John C. Haspert and Jack McKinney; "Large Tunnel Machines", Richard J. Robbins; "Adaptation of Mining Methods", R. L. Loofbourow; "High-Speed, Low-Cost Excavation Methods", J. J. Walsh and Robert Budd; "Underground Shelter Study", Edward Landway; "Planning and Construction of Underground Facilities for Kemano-Kitimat Project", James W. Libby; "Underground Features of the Hanabanilla and Binga Projects", John Lowe, III; "Underground Experience in the Snowy Mountains — Australia", Thomas A. Lang; "Major Underground Excavations of the Pacific Gas and Electric Company", J. Barry Cooke; "Sweden Underground", Lars de Jounge; "Underground Phenomenology", H. L. Brode; "Some Comments on the Wave Propagation Study Group", Samuel M. Genensky; "An Informal Progress Report on Some Theoretical Investigations on the Vulnerability of Deep Underground Openings in Rock", Paul Weidlinger.

154
RESPONSE OF DRAG TYPE STRUCTURES TO BLAST. L. A. Gore and J. J. O'Sullivan. Oct. 1953. 13p. (RM-1151(RAND))

The pressures from a shock wave which produce forces on a target are discussed. These pressures are the static overpressure or pressure rise, and the dynamic or drag pressure. Information is included on the response of two classes of industrial steel structures (heavy steel to support heavy crane equipment and normal steel without heavy crane equipment) to static and dynamic pressures from a nuclear blast. Blast wave duration and the characteristics of static and dynamic pressures as a function of time are also discussed.

155
OVERTURNING OF RIGID STRUCTURES BY BLAST WIND. L. A. Gore and J. J. O'Sullivan. Jan. 1954. 48p. (RM-1235(RAND); ASTIA AD-144272)

A study was made to analyze and determine the essential fundamental conditions that govern whether a structure will overturn when subjected to decaying transient or blast-type wind drag forces. The following structures were included in the study: machinery, coal bins, conveyors, chimneys, a coke oven collecting main, a hot blast furnace stove, and a blast furnace top.

156
DESTRUCTION OF STRUCTURES BY BLAST WIND. L. A. Gore and J. J. O'Sullivan. Feb. 1954. 35p. (RM-1236 (Rand); ASTIA AD-144273)

A study was made to analyze and determine the essential fundamental conditions that govern the collapse or destruction of structures when subjected to decaying transient or blast-type wind drag forces. The following industrial-type structures were included in the study: single and multibay buildings, plate mill runout and finishing building, and an open hearth building.

157
EFFECTS OF ENVIRONMENT IN REDUCING DOSE RATES PRODUCED BY RADIOACTIVE FALLOUT FROM NUCLEAR EXPLOSIONS. J. E. Hill. Sept. 28, 1954. 10p. (RM-1285-1(RAND))

Factors by which the infinite plane dose rate of fission product γ radiation resulting from an atomic explosion would be reduced in various situations are summarized. Reduction rates were calculated for dose rates in open fields, parks, streets of built-up urban areas, and various types of buildings and shelters. Locations offering maximum protection against γ radiation for a civilian population are discussed briefly.

Rensselaer Polytechnic Institute, Troy, New York

158
BUCKLING OF A COLUMN WITH RANDOM INITIAL DISPLACEMENTS. William E. Boyce. Feb. 22, 1960. 18p. (AFOSR-TN-60-150; MathRep-32)

Elementary column buckling theory assumes the column is initially straight, and leads to an eigenvalue problem for the buckling load. For curved columns the phenomenon of buckling in a sense disappears, inasmuch as non zero displacements occur for arbitrarily small loads. The purpose of this paper is to discuss the relation between the load and the mean transverse displacement of the column when the initial configuration of the column is random in nature.

University of Rochester. Atomic Energy Project, Rochester, New York

159
THE SCATTERING OF THERMAL RADIATION INTO OPEN UNDERGROUND SHELTERS. T. P. Davis, N. D. Miller, T. S. Ely, J. A. Basso, and H. E. Pearse. May 1959. 24p. (CEX-58.2)

Animals placed in open underground shelters at the Nevada Test Site during an atomic weapon test suffered skin burns of an unknown origin. From a study of the burns, the following deductions were made: (1) the causative agent entered the shelter from outside; (2) the causative agent was subject to rectilinear propagation near the entrance; and (3) the causative agent required a relatively unobstructed opening to effect entrance. The two most likely agents for such burns are (1) hot winds and/or hot windborne dust that are forced into the shelter as the shock front from the weapon passes the shelter entrances and (2) radiant energy from the fireball that is scattered into the shelter. The purpose of this study was to evaluate the contribution made by radiant energy and, if this contribution proved to be significant, to suggest means of eliminating it. The following procedure was adopted: (1) extensive measurements were made in the laboratory on a scale model of the shelter and (2) direct measurements were made on an actual shelter to ensure the validity of the laboratory results. A Photronic cell and a MacBeth Illuminometer were used to measure the entryway transmission of total radiant energy. The consistency of the results with extended and point sources for the model shelter and the agreement of these results with those from a point source and sunlight for the underground shelter at the Nevada Test Site lead to considerable confidence in the ability to predict the amount of radiant energy that would reach the animals from a weapon of known size. The energy calculated on the basis of these static measurements is about $\frac{1}{200}$ of that required to produce the burns. Although transient effects caused by the rapid heating of the entryway walls could have resulted in a considerable increase in the entryway transmission, it is felt that radiant energy was neither the sole causative agent nor the most important causative agent in producing burns within the shelters. Hot winds and/or hot wind-borne dust are now considered to be the most likely agents.

Safe Manufacturers National Association, New York, New York

160
EFFECTS OF A NUCLEAR EXPLOSION ON RECORDS AND RECORDS STORAGE EQUIPMENT. James L. Gear and William J. Lloyd. (In cooperation with the Office of Civil and Defense Mobilization, Washington, D. C. and National Records Management Council Inc., New York). PROJECT 35.5 [OF] OPERATION TEAPOT. April 1956. 43p. (WT-1191)

In Apple II Burst, materials and storage equipment normally found in government, business, and archival institutions were placed at 11 different unshielded distances from ground zero in a zone where severe damage to surface structures was expected. Other records and equipment were placed within different type structures located (1) in a zone where severe damage was expected and (2) in a zone where little damage was expected. Of 22 units of unshielded storage equipment containing records, only six units were accessible with contents intact. The records and equipment placed within the structures were virtually undamaged. This would indicate that records housed within the type of equipment tested would survive if protected by some type of structure, except for damage resulting from debris, fire, and water. However, the best protection was afforded by the basement (below ground level) of the structures even though the upper stories collapsed and were destroyed.

Sandia Corporation, Albuquerque, New Mexico

161
SHIELDING FROM BLAST WAVES BY PARALLEL STRUCTURES. M. L. Merritt. Oct. 28, 1952. Decl. May 28, 1954. 34p. (AFSWP-224)

Tests were made in order to determine what would be the quantitative effect on the blast loading of a test structure if another similar structure were placed parallel to and between it and the blast. The procedure used was to vary such factors as separation between structures, height of the shield, and depth and length of the shield and to compare forces on the front, top, and back surfaces with those measured on an identical unshielded structure. Data are presented in the form of loadtime curves in which measured average pressures are compared with estimated incident air pressures at the point of measurement. Results confirmed findings of similar shock-tube studies.

162
SELF-SHIELDING FROM BLAST WAVES BY STRUCTURAL MEMBERS. C. C. Hudson. May 1953. Decl. Jan. 6, 1955. 39p. (AFSWP-225)

Interference effects of structural wings on the pressures sustained by the main walls of a building subjected to a moderately weak blast have been investigated using a model structure at the Coyote Canyon blast site. Measurements were made using a panel gage which gave average pressures. The impulse measured on this complex structure was found to be somewhat greater than that measured on a simple structure. Results are compared with those of similar experiments using simple structures and with computations from acoustic theory.

163
BLAST LOADING END EFFECTS I. C. C. Hudson. Aug. 24, 1954. Decl. July 19, 1957. 107p. (AFSWP-461)

Information is presented on studies which propose a theory for the load or force imposed upon a structure by a blast wave, and which support the theory with experimental data from bursts of chemical explosives in the Coyote Canyon Blast Site. Whenever possible the small-scale results are compared with load-time histories measured for nuclear bursts at the Nevada and Pacific Proving Grounds. Three tests are reported which were the most completely instrumented blast studies yet made to study end effects. Theoretical arguments are developed, along with the consideration of the data, which lead somewhat intuitively to equations giving the diffraction pressures on the target. Scaling laws are derived for blast diffraction and are checked both between several Coyote Canyon shots and between Coyote Canyon and full-scale (Greenhouse) tests. Argreement is found to be encouraging although not complete. The end effect is analyzed and found to be negligible for the purposes of present-day structures theory. A historical (space-time) pressure diagram, introduced as a representation of dynamic loading, proves useful in examining many of the physical aspects of blast diffraction. In the strongest blast interaction (25 psi overpressure on an ambient pressure of 12 psi), the space-time diagram shows some evidence of turbulent flow at the structure surface.

164
SOME TESTS OF THE DIFFRACTION OF BLAST WAVES. Melvin L. Merritt. June 7, 1951. 78p. (SC-1803(TR); AECD-3252)

A series of tests was conducted to measure the diffraction about a structure of shock waves from the detonation of high explosives. Two simple geometrically similar structures were used for the tests, each subject to blast waves of two different overpressures and two different durations. Pressure loadings during passage of the shock wave are presented and conclusions drawn from these data. An investigation of the effects of changes in overpressure alone would indicate that diffraction at one pressure is not necessarily similar to diffraction at another.

165
NATURAL FREQUENCIES OF STRUCTURE 3.1.1. Lydik

S. Jacobsen and William M. Wells. Nov. 2, 1951. Decl. Nov. 17, 1959. 59p. OTS. (SC-2090(TR))

Preshot and postshot measurements of the natural frequencies of buildings were made. Various constructions of steel and concrete were tested using a mechanical shaker, and pickup to measure displacements. By use of these data stiffness changes caused by blast loading were calculated. Assuming a rigid foundation, calculated values of preshot frequencies were greater than measured values. Ground stiffnesses appear to be correct. Damping ratios calculated from resonance curves are low compared with values obtained by other experimenters.

166

BLAST LOADING OF STRUCTURES IN THE REGULAR REFLECTION AND LOW MACH-STEM REGIONS. J. P. Murtha. Feb. 1959. 90p. (SC-4239(TR))

An investigation was made of the blast loading on model structures in the regular reflection region and in the region where the height of the Mach stem varies from less than the structure height to several times the structure height. The three structure models employed were 2 × 2 feet in cross section, with lengths of 2, 4, and 18 feet. They were subjected to blast waves from 250-pound charges of TNT detonated at heights of 38, 64, and 90 feet above the surface. When scaled to nuclear burst, these conditions represent a 7-story building subjected to a 20-kt burst. They therefore constitute a situation involving multistory structures. Variations from two-dimensional theory for predicting the pressure loading on the front surface were observed for small zenith angles while variation on the top surface was observed at large zenith angles. Shortening of the positive-pressure duration on the front surface was found to occur in the regular reflection and low Mach-stem regions. The measured times of occurrence for maximum average pressure on the rear face of the 2- × 2- × 18-foot target are in good agreement with times predicted.

167

CURVES FOR ESTIMATING LOW BLAST OVERPRESSURE. L. J. Vortman. April 1958. 4p. (SCTM-195-58(51))

A plot of overpressure versus distance is presented for the fractional psi pressure level. The plot provides a rapid and simple means of estimating the permissible yield at any distance from settled areas. Damage to small-pane windows and large plate glass display windows can be estimated.

168

TESTIMONY DURING SHELTER HEARINGS OF THE MILITARY OPERATIONS SUBCOMMITTEE. L. J. Vortman. May 1958. 30p. (SCTM-217-58(51)

Those full-scale effects tests which relate to protective shelter construction are summarized. Principles of shelter design are discussed. Based on costs of two shelters built at the Nevada Test Site, the cost in dollars and time of a national personnel shelter program is estimated.

169

THE EFFECTS OF NOISE IN BLAST-RESISTANT SHELTERS. F. G. Hirsch, Joan Longhurst, D. R. McGiboney, and H. H. Sander. PROJECT 33.2 [OF] OPERATION TEAPOT. June 1955. 54p. (WT-1180)

(Supersedes ITR-1180) A fatigue syndrome has been observed to develop in animals that experience a nuclear explosion while confined in a blast-resistant shelter. In order to determine the importance of noise as a contributing factor, groups of deafened and nondeafened albino male rats were placed in blast-resistant shelters on two explosions of the Operation Teapot series. Noise measurements were made which showed that noise intensities reached a level as high as 181 db, but only for durations of 35 msec. No differences were found between the deafened and nondeafened rats in the postshot experimental tests. It was concluded that noise in this particular instance was not a parameter of importance in the etiology of fatigue. Many of the animals received significant doses of ionizing radiation. This affected the learning performance of the untrained animals; however, it did not affect the retention of a learned response in the case of the animals that had been trained prior to the explosion. Despite the fact that these trained rats were very ill, they continued to perform the discriminatory act without error.

170

COMPARISON TEST OF REINFORCING STEELS. R. H. Carlson and J. P. Murtha. PROJECT 34.2 [OF] OPERATION PLUMBBOB. Final Report. Oct. 1952. 108p. (WT-1473)

The project was planned to determine the relative merits of rail- and intermediate-grade steel as reinforcement in concrete slabs subjected to blast loading. Slab pairs were placed at ground level over deflection chambers and loaded with the incident pressure pulse from a nuclear device. Two station locations were chosen so that the loadings were approximately 7 and 5 psi peak overpressure. The slabs comprising each pair were identical except for the grade of reinforcement in each. Slab strengths were varied, and two test stations were used to increase the probability of realizing the response necessary to emphasize the advantages of each steel grade. Measurements were made of the dynamic midspan slab deflections and the transient loading pulse. A thorough posttest survey was conducted to determine the severity of the resulting damage to the concrete slabs. Test results indicated that the desired range of slab behavior was achieved. In all cases the rail slabs displayed the more desirable response. However, limitations of this experiment, due to loading the structural conditions, must be considered before this conclusion can be generalized.

Stanford Research Institute, Menlo Park, California

171

SYSTEMS ANALYSIS OF RADIOLOGICAL DEFENSE. Kendall D. Moll. Nov. 1958. 124p. (NP-7241)

A comparison was made of various civil defense systems and programs for radiological protection during the early post-attack period. Topics considered in detail include the effectiveness and feasibility of various types of conventional buildings when used as shelters, the effectiveness, feasibility, and cost of decontamination, evacuation both before and after fall-out arrival, fall-out hazards, warning and communications systems, administration and supporting services, and program costs and effectiveness.

Stanford University, Stanford, California

172

INVESTIGATION OF SHEAR WALLS. Part 3. EXPERIMENTAL AND MATHEMATICAL STUDIES OF THE BEHAVIOR OF PLAIN AND REINFORCED CONCRETE WALLED BENTS UNDER STATIC SHEAR LOADING. Harry A. Williams and Jack R. Benjamin. (In cooperation with the Corps of Engineers.) July 1, 1953. Decl. April 18, 1960. 141p.

A research program involving the investigation of definite items influencing shear wall behavior is presented and a study of the mathematical prediction of shear wall behavior is also discussed. Information is included on the following: (1) an investigation of the shear stress distribution in a roof slab and the connecting shear wall as a function of the type of load applied to the roof; (2) an investigation of the influence of wall length on shear wall as a function of the type of load applied to the roof; (3) an investigation of the influence of wall length on shear wall behavior keeping the height and frame constant (both plain and reinforced concrete model walls were investigated); (4) a study of the influence of normal as well as shear load on wall behavior for plain concrete model walls; (5) a study of the influence of frame proportions on wall behavior keeping the wall constant; (6) an investigation of the influence of various amounts of tension column steel on type of wall failure; (7) studies of scale effect for plain and reinforced concrete walls; (8) methods of mathematical and empirical prediction of shear wall behavior; and the development of lattice analogy with emphasis on reduction of time required for a solution.

173
INVESTIGATION OF SHEAR WALLS. PART 4. EXPERIMENTAL AND MATHEMATICAL STUDIES OF THE BEHAVIOR OF BRICK WALLED BENTS UNDER STATIC SHEAR LOADING. Harry A. Williams and Jack R. Benjamin. (In cooperation with the Corps of Engineers.) Aug. 1, 1953. Decl. May 17, 1954. 36p. (AFSWP-408)

Experimental data and mathematical predictions are presented on the behavior of brick walled bents under static shear loading. Information is included on the following items: (1) the influence of the length-height ratio on wall behavior; (2) the influence of variations in frame on wall behavior; and (3) the properties of brick masonry.

174
INVESTIGATION OF SHEAR WALLS. PART 5. PREDICTION OF THE BEHAVIOR OF THE PLAIN CONCRETE, REINFORCED CONCRETE, AND BRICK WALLED BENTS UNDER STATIC SHEAR LOADING. Harry A. Williams and Jack R. Benjamin. (In cooperation with the Corp of Engineers.) Aug. 1, 1953. Decl. May 17, 1954. 54p. (AFSWP-409)

The purpose of this report is to present simplified procedures for the predictions of the behavior of concrete-walled and brick-walled one-story bents. The methods suggested are believed to be the simplest possible procedures consistent with a reasonable degree of accuracy. Where the lattice analogy is used, the result is reduced to a simple formula. Simple strength of materials theory is suggested for some problems. The reasoning behind the methods of prediction is included along with supporting data, although derivations are not given in detail. The sections on concrete-walled and brick-walled bents are each concluded with a procedure summary and illustrative examples.

174a
INVESTIGATION OF SHEAR WALLS. Part I. Experimental Behavior and Empirical Results. Plain Concrete and Brick-Walled Bents Under Static Shear Loading. Harry A. Williams and Jack R. Benjamin. April 1, 1952. 73p.

An investigation was made of plain concrete-walled and brick-walled single story building bents subjected to static shear loading. Results indicate that models which are corner loaded with compressive forces along a diagonal are not comparable in behavior with those subjected to cantilever loading. Scale model effect was investigated for brick-walled bents and it was concluded that simple geometrical scaling is satisfactory for the models tested. It is questionable whether models with very heavy frames would give comparable results.

174b
INVESTIGATION OF SHEAR WALLS. Part 2. Prediction of Behavior of Plain Concrete and Brick-Walled Bents Under Static Shear Loading by Lattice Analogy. Jack R. Benjamin. April 1, 1952. 74p.

A mathematical prediction of shear wall behavior under static load by the use of the lattice analogy is discussed. The uncracked behavior, and ultimate load were predicted with satisfactory accuracy by the lattice analogy procedure. Predictions and experimental verification are confined to shear walls of one proportion under a static shear load. The results with brick-walled bents are excellent. Predictions of the behavior of plain-concrete model shear walls are excellent except for the ultimate load. The mathematical procedures involved in the solution of a shear wall by the lattice analogy are presented in detail. The fundamental procedures have been organized and simplified greatly reducing the time required for a solution.

Strategic Bombing Survey

175
THE EFFECTS OF THE ATOMIC BOMB ON HIROSHIMA, JAPAN. Volume I. [Survey conducted October 14—November 26, 1945] May 1947. Decl. April 10, 1950. 131p. (NP-1557)

The objectives of the survey of Hiroshima were the collection, analysis, and evaluation of (1) data pertaining to physical damage caused by the detonation of the first nuclear bomb used as a military weapon, and (2) data on the similarities and differences between the nuclear bomb and the conventional high-explosive and incendiary bombs with respect to physical damage. Data are included on damage to buildings, bridges, services and utilities, machine tools, and stacks. A description of the city, which includes typical dwellings, is presented, and a photographic summary is included. (See also NP-1558, NP-1559, NP-1560, NP-1561, and NP-1562.)

176
THE EFFECTS OF THE ATOMIC BOMB ON HIROSHIMA, JAPAN. Volume II. [Survey conducted October 14—November 26, 1945] May 1947. Decl. April 10, 1950. 660p. (NP-1558)

This volume presents data on the extent of fire in Hiroshima resulting from the nuclear explosion, plus an analysis of the contributing factors. Information is given on blast and fire damage to various types of Hiroshima buildings. Included are data sheets, photographs and drawings detailing the construction and damage to individual buildings studied. (See also NP-1557, NP-1559, NP-1560, NP-1561, and NP-1562.)

177
THE EFFECTS OF THE ATOMIC BOMB ON HIROSHIMA, JAPAN. Volume III. [Survey conducted October 14—No-

vember 26, 1945] May 1947. Decl. April 10, 1950. 378p. (NP-1559)

This volume presents data on the following types of installations and equipment that were exposed during the explosion of the nuclear bomb in Hiroshima: damage to machine tools by blast, debris, fire and exposure to weather; damage to bridges; and damage to services and utilities. (See also NP-1557, NP-1558, NP-1560, NP-1561, and NP-1562.)

178

EFFECTS OF THE ATOMIC BOMB ON NAGASAKI, JAPAN. Volume I. [Survey conducted October 13—November 20, 1945] June 1947. Decl. April 10, 1950. 437p. (NP-1560)

The objectives of the survey made at Nagasaki were the collection, analysis, and evaluation of (1) data pertaining to physical damage caused by the detonation of the second nuclear bomb ever used in warfare as a military weapon, and (2) data on the similarities and differences between the effects of the nuclear bomb and of conventional high-explosive and incendiary bombs with respect to physical damage. Data are included on the extent and nature of damage to buildings, bridges, public utilities, transportation facilities, communications, machine tools and special equipment. This volume mainly consists of the effects of the nuclear detonation on industrial structures. Included also are a description of the city, photographs, and a large map of the city. (See also NP-1557, NP-1558, NP-1559, NP-1561, and NP-1562.)

179

EFFECTS OF THE ATOMIC BOMB ON NAGASAKI, JAPAN. Volume II. [Survey conducted October 13—November 20, 1945] June 1947. Decl. April 10, 1950. 365p. (NP-1561)

This volume presents data on the effects of the nuclear explosion at Nagasaki on educational, medical, municipal and other public buildings. The various types of structures are described, and photographs and a large map of the city are included. (See also NP-1557, NP-1558, NP-1559, NP-1560, and NP-1562.)

180

EFFECTS OF THE ATOMIC BOMB ON NAGASAKI, JAPAN. Volume III. [Survey conducted October 13—November 20, 1945] June 1947. Decl. April 10, 1945. 277p. [NP-1562]

The object of this volume is to describe and analyze the damage sustained by the equipment in the various manufacturing plants in Nagasaki and to compare the nuclear bomb damage with that caused by high-explosive bombs. Included also is a description of protective measures and their effectiveness against air attack. (See also NP-1557, NP-1558, NP-1559, NP-1560, and NP-1561.)

181

THE EFFECTS OF ATOMIC BOMBS ON HIROSHIMA AND NAGASAKI. [Survey began Sept. 1945.] June 30, 1946. 55p.

The results of the nuclear bombs detonated over the Japanese cities of Hiroshima and Nagasaki are described. Damage to structures and casualty rates are discussed in detail. The effects of these bombings on the outcome of the war is considered; an attempt is made to evaluate the psychological effects of this type of warfare. A short description of the fundamental theories and principles of the nuclear bomb is given. A bibliography listing 208 other U. S. Strategic Bombing Survey reports is presented.

Syracuse University. Research Institute, Syracuse, New York

182

COMPOSITE MATERIALS AND COMPOSITE STRUCTURES. Proceedings of the Sixth Sagamore Ordnance Materials Research Conference Conducted at Sagamore Conference Center, Racquette Lake, New York, Aug. 18, 19, 20, and 21, 1959. 559p. (NP-8444; MET-661-601; PB-161443)

Twenty-two papers were presented at the conference. The subjects included were composite materials and structures, aspects of strengthening of composites, metallic composites, glass reinforced plastics, composite pressure vessels, and composite systems for thermal protection.

183

AN EXPERIMENTAL EVALUATION OF THE RADIATION PROTECTION AFFORDED BY A LARGE MODERN CONCRETE OFFICE BUILDING. J. F. Batter, Jr., A. L. Kaplan, and E. T. Clarke. May 1, 1959. 60p. (CEX-59.1)

An experimental study was made to determine the effective shielding provided by a modern reinforced-concrete office building (AEC Headquarters building) from nuclear fallout. Pocket ionization chambers were used for measurement of the radiation-field strength. Fallout was simulated with distributed and point-source configurations of Co^{60} and Ir^{192} sources. Four typical sections were selected for study, and experiments were performed on each. These included an external wing with exposed basement walls and an external wing with a buried basement. Roof studies were made on an internal wing with a full basement and on the east end of wing A, which has a thin-roof construction. The thick-roof construction of 8 in. of concrete and 2 in. of rigid insulation covers all the building except the east end of wing A, which has 4 in. of concrete and 2 in. of insulation.

University of Utah, Salt Lake City, Utah

184

X-RAY TECHNIQUES FOR MEASURING DENSITY VS DISTANCE RELATIONSHIPS IN DETONATING EXPLOSIVES. Technical Report No. LIV. T. K. Collings. Sept. 30, 1958. 24p. (NP-7994)

Reinforced concrete instrument shelters constructed to house x-ray detecting recording equipment are described. In addition circuitry for use with the x-ray equipment in detail are given. Descriptions of equipment tests are given, and problems encountered in operation are discussed. Diagrams and photographs are included.

Waterways Experiment Station, Vicksburg, Mississippi

185

GROUTING CONSULTING SERVICE. James M. Polatty, Ralph A. Bendinelli, Melvin Glass, and Bill J. Houston. Dec. 1958. 21p. PROJECT 26.12 of OPERATION HARDTACK, PHASE II. (WT-1713)

The drilling and grouting operations conducted in connection with the underground nuclear detonations of Operation Hardtack, Phase II, are described in detail. The composition of the four grouting mixtures used is given. Also, hourly time logs are included as tables of the drilling of the four holes.

Westinghouse Electric Corporation. Atomic Power Department, Pittsburgh, Pennsylvania

186

DECONTAMINABILITY OF STRUCTURAL MATERIALS AND SURFACE COATINGS FOR USE IN NUCLEAR INSTALLATIONS. R. Lloyd. May 28, 1957. 18p. (WAPD-PWR-CP-3052)

A standard procedure for washing under rigorously reproducible conditions was used to clean radioactive contamination from a variety of surface coatings and structural materials. Specific data on the clean-up properties of these materials are tabulated.

187

ENERGY CAPACITY OF ELASTIC-PLASTIC BEAMS. C. M. Friedrich. June 1955. Decl. July 18, 1956. 34p. (WAPD-TN-511)

A procedure is presented for calculating strains and deflections in elastic-plastic steel beams in terms of energy capacity or starting velocity. Graphs based on the calculations for quick determination of peak strain, maximum permanent strain, peak deflection, maximum permanent deflection in steel beams of various cross sections, and loading conditions are given.

Wright Air Development Center. Materials Laboratory, Wright-Patterson Air Force Base, Ohio

188

THE EFFECTS OF NUCLEAR RADIATION ON MILITARY SPECIFICATION PAINTS. Period covered: Sept. 1955 to Aug. 1956. Lloyd A. Horrocks. March 15, 1957. 29p. Project title: FINISHES AND MATERIALS PRESERVATION. Task title: ORGANIC PROTECTIVE COATINGS. (WADC-TR-57-186; AD-142143; PB-131599)

This report is an evaluation of the effects of gamma radiation and heat on several available types of specification and non-specification paints. Reflectance, adhesion, abrasion, humidity, and film condition data are presented on the effects of gamma radiation and heat on silicone-alkyd, fluorocarbon, alkyd, nitrocellulose, phenolic, and epoxy resin-based paints. Silicone-alkyd, alkyd, and phenolic resin-based paints appear to be satisfactory for use after exposure to 1×10^9 roentgens.

Journal Articles

188a

UNDERGROUND OFFICES SERVE DELAWARE CD CENTER. Am. City, 72: No. 7, 122-3(July 1957)

Delaware's civil defense control center, which is located in what had formerly been an abandoned mortar bunker known as Fort du Pont, is described. The structure is both blast- and radiation-proof by virtue of the 32-foot-thick layers of earth, concrete, and steel that cover its roof and walls. The center has been designed in full recognition of the inherent limitations in civil defense. Thus the center has been organized to serve strictly as a communications headquarters, a clearing center where data from the field will be received, processed for different sections, coordinated by defense and state officials, and where directives based on such information will be transmitted immediately to all corners of the state.

188b

BLAST-RESISTANT BUILDINGS. Ellery Husted and G. L. Schuyler. Architectural Forum. 95: No. 5, 164(Nov. 1951)

A description is given of a building design combining a normal exterior, adequate light and air for outside rooms and a blast-resistant interior of heavy shear-wall and roof construction designed for plastic yield. Within such a building occupants and essential facilities may be given a good degree of protection against nuclear bomb damage.

188c

BLAST-RESISTANT BUILDINGS. Bruce G. Johnston. Architectural Forum. 101: No. 1, 164, 178, 182, 186(July 1954)

A multistory blast-resistant structure of a tough cylindrical core inside a frangible shell is discussed. The following construction considerations are reviewed: protection against radiation, resistance against external pressure, effect of air gust, and reduction of fire hazard. The suggested structure is of circular plan with a cylindrical core in the center running through the complete height of the building. Preliminary design studies indicate that 10- to 12-story buildings of this type of construction will withstand blast effects of a nominal nuclear explosion at relatively close range.

189

SWEDES MAKE ROCK TUNNEL HISTORY. Waldo G. Bowman. Eng. News-Record 155, No. 9, 34-37; 40; 42; 44(1955) Sept.

The Swedish underground program, two hydro plants and an air raid shelter-garage, is discussed. Reasons for their success are given and information on the characteristics of terrain and geology are included. Tunneling methods and operations are also presented.

190

PRECAST CONCRETE OFFERS PROTECTION AGAINST ATOMIC BLAST. Arsham Amirikian. J. Am. Concrete Inst. 22, 497-516(1951) Mar.

Precast concrete is reported as an excellent means for providing protection against an atomic blast. The technique is indicated as suitable for new construction and is adaptable to existing structures by providing them with a protective shell. Readily assembled framing elements can be prefabricated at regional plants and stored or stockpiled at various points for immediate use in an emergency. For design purposes, in this paper, shelters are divided into three groups in relation to their proximity to a probable target. Suggested arrangements and main details of assembly of a number of types of precast framing suitable for each group are presented. A general discussion of the protection problem, the needed weapons data, and design criteria are also given.

191

HEAVY STEEL-AGGREGATE CONCRETE. E. I. Fiesenheiser and B. A. Wasil. J. Am. Concrete Inst. 52, 73-82 (1955) Sept.

An experimental study of various mix proportions for heavy concrete is described and a proportioning procedure for concrete of given strength and density is explained. The primary object of the investigation was to determine a procedure for the improved proportioning of mixes using steel punching as coarse aggregate with steel shot of varying size as fine aggregate. First, the individual ingredients were investigated, then, the optimum mixture. Various heavy concrete mixes were made and strength tested at 7, 14, and 21 days. Test results are interesting in that they indicate a possible conclusion that the strength of this concrete is proportional to its density, the water-cement ratio being only one of the factors involved in determining the density. This suggests the generalization that, in the plastic range, the strength of any concrete of given ingredients is proportional to its density.

191a

MEASUREMENTS OF DIFFRACTION OF SHOCK WAVES AND RESULTING LOADING OF STRUCTURES. W. Bleakney, D. R. White, and W. C. Griffith. J. Appl. Mech. 17, 439-45(1950).

This paper is concerned with the evolution in time of a flow pattern about an obstacle initially in still air, passed over by a sudden front of high-speed flow induced by a shock wave, the stream approaching a steady configuration.

192

LARGE PLASTIC DEFORMATIONS OF BEAMS UNDER TRANSVERSE IMPACT. E. H. Lee and P. S. Symonds. J. Appl. Mech. 19, No. 3(1952) Sept.

A method of analysis is shown that was developed to determine the deformation in a beam subjected to a transverse impact force. The analysis represents an attempt to calculate the permanent deformation of a bar of ductile material. The approximate final permanent deformation is obtained; this includes deformation during application of the load, and plastic flow which continues afterward when the kinetic energy of the motion generated by the impact is transformed into additional plastic deformation. A criterion is given for conditions when this type of theory can be expected to provide a satisfactory analysis. The method of solution provides an interesting analogy to the concept of static deformation which has been used in the analysis of quasi-static plastic-flow problems. (See also "Dynamic Load Characteristics In Plastic Bending of Beams." J. Appl. Mech. 20.)

193

DYNAMIC LOAD CHARACTERISTICS IN PLASTIC BENDING OF BEAMS. P. S. Symonds. J. Appl. Mech. 20, (1953) Dec.

The numerical analysis of large plastic deformations of beams subjected to transverse dynamic loads is discussed. Results are presented for three types of force pulse: a rectangular pulse, a half-sine wave, and a triangular pulse. These show that the central angle of permenent deformation for all three cases can be computed from the empirical formula $\theta_0 = CI^2P_m^{2/3}$, where I is the impulse, P_m is the maximum load value, and C depends on the dimensions and properties of the beam, with a numerical factor that varies by about ±15 per cent from the value for the half-sine wave pulse to those for the other two pulse types. (See also "Large Plastic Deformations of Beams Under Transverse Impact." J. Appl. Mech. 19.)

194

ATTENUATION OF GAMMA RAYS. I. TRANSMISSION VALUES FOR FINITE SLABS OF LEAD, IRON, AND THE COMPTON SCATTERER. Glenn H. Peebles. J. Appl. Phys. 24, 1272-87(1953) Oct.

An approximate integral recursion formula is developed which gives a relation between the probability that a photon will be transmitted through a slab of finite thickness with exactly k + 1 collisions and the probability that it will be transmitted with exactly k collisions, where the latter probability is known for suitable ranges of slab thickness, of incident energy, and of incident angle. A similar formula also exists for the expected energy transmitted. The two recursion formulas have been used to calculate the transmissions with one, two, and three scatterings for photons incident on slabs of Pb and of Fe, and from these calculated transmissions the "build-up" factors have been estimated. The build-up factor for normally incident photons of 1 to 20 mc^2 are given for Pb slabs and for Fe slabs having a thickness of 0 to 20 mean free paths. A second method, which considers the transmission through a thick slab as a succession of transmissions through thin slabs, is used to check the estimates of the build-up factor obtained by the first method. This second method provides additional information in the form of the distributions of the transmitted photons. Finally, some transmission and reflection values for thin slabs of the Compton scatterer are presented along with some results for air which are obtained by the second (thin-slab) method.

195

ATTENUATION OF GAMMA RAYS. II. TRANSMISSION VALUES FOR VARIOUS MATERIALS AND GEOMETRIES. Glenn H. Peebles (RAND Corp., Santa Monica, Calif.). J. Appl. Phys. 24, 1437-47(1953) Dec.

A discussion of the effect of variation of the total absorption coefficient on γ-ray transmission probabilities is given, which leads to estimates of the build-up factors for material of arbitrary atomic number Z. Estimates are made of the photon and energy densities arising from a plane of sources, a line of sources, and a point source in an infinite homogeneous medium, where the material of the medium is (1) Fe and (2) Pb.

196

RADIATION-RESISTANT BUILDING BLOCK. Rudolf Alberti. British Patent 826,793. Jan. 20, 1960.

A radiation-resistant building-block design is presented. The block can be used for constructing walls, rooms, or chambers to prevent radiation from penetrating. The block is rectangular with a 120° notch on one end and 120° point on the other end, making it especially suitable for constructing hexagonal containers. The material used is barite concrete to which a sheet metal casing can be applied with $BaSO_4$ filling.

197

SAMPLE CALCULATIONS OF GAMMA-RAY PENETRATION INTO SHELTERS: CONTRIBUTIONS OF SKY SHINE AND ROOF CONTAMINATION. Martin J. Berger and James C. Lamkin. J. Research Natl. Bur. Standards 60, 109-16(1958) Feb.

An approximate method is presented for calculating the penetration of gamma radiation in shelters. Sample calculations, for an assumed source energy of 1 million electron volts, are given for the following problems: (1) Dose rate inside houses and underground shelters whose roofs are covered with radioactive fallout, and (2) dose rate in open holes due to reflected radiation (sky shine) from fallout contamination on the surrounding ground. A detailed examination is made of the dependence of the dose rate in a shelter on the shape of the shelter, and on the position of the detector within the shelter. The estimated accuracy of the calculations is ±30 percent.

REFERENCES

198
BROAD AND NARROW BEAM ATTENUATION OF Ir^{192} GAMMA RAYS IN CONCRETE, STEEL, AND LEAD. Victor H. Ritz (National Bureau of Standards, Washington). J. Soc. Non-Destructive Testing 16, 269-72(1958) May-June.

Broad and narrow beam attenuation curves were obtained experimentally for Ir^{192} gamma rays in concrete, steel, and lead. The results were compared with those of other workers. The narrow beam attenuation curves were found to agree with calculated theoretical curves.

199
NUCLEAR BLAST DESIGN. David L. Narver, Jr. Los Angeles and Washington, D. C., Holmes and Narver, Inc., [1955?]. 12p.

The effects of blast forces on structural walls and buildings are discussed. Factors affecting the path and force of shock waves are discussed and diagrammed. In the case of nuclear explosions radioactivity and re-entry into a building that has withstood a blast are considered briefly.

200
[TYPES OF CONSTRUCTION WHICH MAY GIVE PROTECTION FROM THE EFFECTS OF AN ATOMIC EXPLOSION.] Charles Owen Brown. Ind. Eng. Chem. 43, 57A-58A, 60A (1951) Jan. (Equipment and design)

It is shown that structures are subjected to a blow from the right and then immediately subjected to one from the left following an atomic bomb explosion. The interior of the structure is subjected to increased pressure and then to negative pressure, and then the pressure becomes normal. Minor forces also act on the structure as the wave passes it. A weak, reflected wave is developed by the front of the building, and, as the main wave passes the building, eddy currents and reduced pressure areas develop back of the building for each passage of the main wave. Designs and types of construction of buildings are suggested for the protection of people and equipment and to preserve production facilities.

201
HOW NUCLEAR RADIATION AFFECTS ENGINEERING MATERIALS. D. O. Leeser (Argonne National Lab., Lemont, Ill.). Materials and Methods 40, 110-20(1954) Aug.

The effects of various radiation intensities on the mechanical and physical properties of metals (stainless steels, carbon steels, Ni, Ni alloys, Zr, Tantalloy, W, Tantung G, Ta, and Co alloys) and nonmetals (elastomers, electric insulators, plastics, and oils) are given. Results are tabulated. The mechanisms of radiation damage and test procedures are discussed.

202
CONCRETE OR LIKE CONSTRUCTIONAL MATERIALS AFFORDING PROTECTION AGAINST NUCLEAR RADIATIONS. J. H. Fischel and L. Martin. British Patent 805,752. Nuclear Eng. 4, 324(1959) July-Aug.-Sept.

A material suitable for use in the construction of protective buildings is described. A natural or artificial barium compound to afford protection against alpha, beta, and gamma rays and graphite to afford protection against neutrons is used in admixture with a hydraulic binding material. The most convenient and inexpensive barium compound is the natural form known as barytes or heavy spa. The proportion of the barium compound and graphite should be 60 to 86%, and of the cement 40 to 14% (by weight).

203
STATIC AND DYNAMIC ELASTIC BEHAVIOR OF REINFORCED CONCRETE BEAMS. Joseph Penzien and Robert J. Hansen. Proc. Am. Concrete Inst. 50, 545-67(1954).

Laboratory investigations of static and dynamic elastic behavior of reinforced concrete beams are described. Results indicate that strains of concrete and steel may be predicted with reasonable accuracy for both static and dynamic conditions of loading provided that (a) proper allowance is made for the effects of creep and cracking of the concrete, and (b) that an exact dynamic theory be used with allowance for damping for the dynamic condition of loading.

204
DESIGN OF BLAST RESISTANT CONSTRUCTION FOR ATOMIC EXPLOSIONS. C. S. Whitney, B. G. Anderson and E. Cohen. Proc. Am. Concrete Inst. 51, 589-683(1954-55).

Methods and principles used in designing the first full scale blast resistant structures tested at Eniwetok are presented and the test results are cited in support of the procedures outlined. Economic and other practical considerations are discussed. Radiation hazards and methods of dealing with them are described. Appendixes are included which give detailed procedures for computing the blast loading, for designing individual structural elements and single and multistory buildings in both the elastic and plastic range for this loading, for computing ultimate strength of structural elements and frames under rapid loading, and for dealing with some special problems.

204a
AN ENGINEERING APPROACH TO BLAST RESISTANT DESIGN. N. M. Newmark. Proc. Am. Soc. Civil Engrs., 79: 16p. (Oct. 1953).

An approach which can be used for making preliminary designs of structures to resist blast loadings resulting from nuclear detonations is presented. The procedure involves the selection of the required yield resistance of the structure to resist the blast forces. The duration of the pulse and the ductility of the structure must be considered in the solution of the problem. However, once the necessary yield resistance is determined, the rest of the design is essentially like the ordinary routine for static loads. After the preliminary design is made, better values of the period of the structure and of its ductility factor can be computed. The procedure can be applied again to determine whether the strength of the structure is adequate.

204b
BLAST RESISTANT BUILDING FRAMES. Bruce G. Johnston and Archie Mathews. Proc. Am. Soc. Civil Engrs., 81: 26p. (May 1955).

Suggestions are made for good practice that will reduce damage suffered by industrial building frames if they are subjected to enemy bombing attacks. The suggestions are intended to apply primarily to a particular type of industrial building meeting the following restrictions: (1) one-story steel frame construction and (2) buildings that contain heavy machinery or other durable contents not liable to serious damage as a result of high winds of tornado proportions. General factors are included which favor maximum plastic resistance of steel beams, columns and details, applicable to all classes of steel construction wherein increased resistance to bomb attack is desired. A design example is presented.

205
DESIGN OF MULTI-LEVEL GUYED TOWERS: WIND LOADING. Edward Cohen and Henri Perrin. Proc. Am.

Soc. Civil Engrs. J. Str. Div. 83 ST5, Paper 1355, 1-29 (1957) Sept.

An investigation has been made of wind loadings in order to establish design criteria for multi-level guyed towers. Average wind velocity and gust factor, the variation of wind and gust velocity with altitude, the transformation of wind velocity into pressure, types of structures and shape factors, and ice loading are considered.

205a

EXPERIMENTAL INVESTIGATION OF THE BLAST LOADING ON AN IDEALIZED STRUCTURE. J. Penzien. Proc. Soc. Exptl. Stress Anal., 11: No. 2, 91-106(Publ. 1954)

An experimental method is described for measuring the blast loading on an idealized structure. This includes a discussion of the instrumentation. Presented also are the results of twenty high-explosive tests designed to show the manner in which blast loading on a rectangular two-dimensional structure is influenced by: (1) changing the angle of incidence of the blast wave; (2) placing openings of various sizes and configurations in the structure; and (3) changing the intensity of the blast wave. Experimental data indicate that the integrated blast loading over a large area can be satisfactorily measured using panels having a light stiffness to weight ratio, and using special dynamometers and appropriate electronic recording equipment. The duration of loading on the front side of a structure is in general considerably shorter than the duration of the positive ground level air pressure of the blast wave. Openings present in a structure have a considerable effect on the net lateral blast loading. However, their effect on individual wall and roof surfaces is much greater. Specific location or configuration of openings in a structural panel has a rather small influence on the magnitude of loading; however, the resultant force location changes considerably.

206

THE ATTENUATION OF GAMMA RAYS AT OBLIQUE INCIDENCE. F. S. Kirn, R. J. Kennedy, and H. O. Wyckoff (National Bureau of Standards, Washington, D. C.). Radiology 63, 94-104(1954) July

Attenuation data have been taken for radiation incident obliquely upon barriers of lead, concrete, or concrete-equivalent material. The gamma radiation from Co^{60}, Cs^{137}, and Au^{198} was used at angles of incidence 0, 30, 50, 60, and 70°. The results show that for oblique angles of incidence the Compton-scattered radiation may have shorter path lenths through the barrier. For the large angles of incidence, the obliquity effect must be considered in designing barrier requirements. For a diverging cone of radiation, the effect is not too significant for attenuations less than 100. It is also shown that, in the range of energies below 0.7 Mev, the addition of a layer of lead behind a low atomic number barrier can be effective in reducing the thickness requirements of the barrier.

207

AN ENGINEERING APPROACH TO BLAST RESISTANT DESIGN. Nathan M. Newmark (Univ. of Illinois, Urbana). Trans. Am. Soc. Civil Engrs. 121, 45-64(1956).

The problem of blast-resistant design is approached directly by means of reasonable simplifying assumptions. The resulting design procedure avoids time-consuming and misleading analysis. The procedure and the necessary mathematical relationships are presented and their practical application is explained.

Translations

208

ATOMIC SHELTERS FOR THE MEDICAL SERVICE. (Abris anti-atomiques pour le Service de Sante). J. Tripod. Translated from Vjschr. schweiz. SaintOff 34, 262-9(1957). 9p. (AEC-tr-3404)

Field fortifications are described which are designed to serve as shelters for medical units engaged in the emergency treatment of casualties during radiological warfare. Three of these earth and concrete shelters were build in an average of 480 man-hours each.

209

BENDING OF JOIST AGGREGATES. (Über die Biegung von Trägerrosten.) S. Timoshenko. Translated for Oak Ridge National Lab. from Z. Angew. Math. u Mech. 13, 153-9(1933). 14p. (AEC-tr-3545)

An approximation solution is presented, which is obtained by the use of trigonometric series for the elastic lines of the joists for the case of a joist aggregate consisting of several identical joists which have been distributed at equal distances from each other and which are supported by one or several girders. The approximation formulas obtained in this manner for the greatest deflection of the girders are very simple and can be utilized to advantage in practical calculations.

210

HOW TO PROTECT ONESELF FROM THE ACTION OF ATOMIC WEAPONS. CHAPTER IV. SHELTERS AND PERSONAL MEANS OF PROTECTION. Wladyslaw Panufnik. Translated from Chapter IV, p.99-116 of Jak Chronic sie Przed Dzialaniez Broni'atomowej. 13p. (AEC-tr-3671)

Characteristics of safe shelters for the civilian population in the event of radiological warfare are discussed. It is assumed that in case of an atomic war everyone would carry a container with a gas mask, a little food and water, and personal clothing, and that women and children would always have available a long, white, protective blanket to cover the body from head to toe. When on the street everyone would learn to locate a shelter nearby. Shelters for large buildings would have two entrances and an exit located away from the walls of the building. Doors should be airtight double doors. The shelter would be resistant to shock waves and to debris from the upper floors. It would be hermetically tight against the penetration of the pressure of shock waves. A ventilation system would provide filtered ventilation. The shelters should be stocked with first aid equipment and provisions for a short stay. Other types of shelters described include a shelter for 150 people to be built in an open space and having a vault protruding only slightly above ground, a wood-soil shelter to accommodate 30 to 40 people, a ditch dug in the ground and fitted with walls and a roof, and home shelters in the corner of a basement. The behavior of people during an emergency such as an atomic explosion, individual means of protection against radioactive materials, and the possibility of the contamination of food and water supplies are discussed.

211

EXCERPTS FROM "ATOMIC WEAPONS AND ANTI-ATOMIC DEFENSE." A. P. Glushko, L. K. Markov, and A. P. Pilyugin. Translated from Atomnoye oruzhiye i Protivanomnaya Zashchita, Moscow, 1958, pp.207-385. (JPRS(NY)-L-475)

Factors affecting the radioactive contamination of an area during atomic explosions are discussed. Procedures and equipment for the protection of armies during radiological warfare are described. Design features of shelters are described and illustrated. Radiation detection instruments which may be used as monitors and dosimeters are described. Means of insuring the operation of troops in a locally contaminated area are also included.

Books

212

BLAST RESISTANT BUILDING FRAMES. Bruce G. Johnston and Archie Mathews. 26p. Proceedings American Society of Civil Engineers. Vol. 81 (Separate No. 695) May 1955. Engineering Mechanics Division. $0.50 from ASCE, 33W. 39th St., New York 18, N. Y.

The primary purpose of this paper is to make specific suggestions for good practice that will reduce damage suffered by industrial building frames if they are subjected to enemy bombing attacks. The suggestions are intended to apply primarily to the following industrial-type buildings: one-story steel-frame structures, and buildings containing heavy machinery or other durable contents not liable to serious damage as a result of high winds of tornado proportions. The nature of the structural effects of the nuclear explosion are discussed with emphasis on wind gust aspect of the blast wave. A discussion is included of general factors favoring maximum plastic resistance of steel beams, columns and details, applicable to all classes of steel construction wherein increased resistance to bomb attack is desired. Observance of such rules of design will also result in improved resistance to earthquake and other kinds of shock load wherein plastic strength is important. A design example is presented.

213

THE BOMB, SURVIVAL AND YOU. Fred N. Severud and Anthony F. Merrill. 266p. Reinhold Publishing Corporation (1954).

This book deals with how to design structures to withstand loads from nuclear explosions and the possibilities of survival during a nuclear attack. Information is presented on Hiroshima and Nagasaki structural damage, fire protection, types of shelters, the protection of essential equipment, the protection afforded by existing structures, how to strengthen existing structures, the design of windowless structures, the protective design of new structures, and dispersal. (See also The Bomb, Survival and You, Technical Supplement.)

214

THE BOMB, SURVIVAL AND YOU—Technical Supplement. Fred N. Severud and Kurt Bernhard. 43p. Reinhold Publishing Corporation, New York (1955).

This supplement presents a mathematical analysis of blast loading in order to aid structural engineers in a design procedure. For simplicity, this analysis deals only with investigating members of predetermined sizes and reinforcement. The typical structural element considered is a one-way reinforced concrete slab. The slab is assumed to be fixed at the two supports; this condition may also apply to continuous slabs with equal spans if they are build in at the outer ends. In practical application this analysis will produce sufficiently accurate results for actual investigation requirements.

215

STRUCTURAL DESIGN FOR DYNAMIC LOADS. Charles H. Norris, Robert J. Hansen, Myle J. Holley, Jr., John M. Biggs, Saul Namyet, and John K. Minami. New York, McGraw-Hill Book Co. Civil Engineering Series. 1959, 466p.

The behavior of steel, steel elements, concrete, and concrete structural components under dynamic loading is summarized. Calculations of the response of various structural systems to dynamic loads and computational techniques applicable to response calculations are presented. Applications of blast-resistant and earthquake-resistant design are also summarized.

Congressional Hearings

216

[EFFECTS OF NUCLEAR WEAPONS]. STATEMENT OF DR. FRANK SHELTON. P. 15—43 of "Biological and Environmental Effects of Nuclear War. Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, Eighty-Sixth Congress, First Session, June 22-26, 1959. Part I."

The effect of a nuclear war is the sum of the effects of the weapons employed against the individual targets. The effects of blast, thermal radiation, and prompt nuclear radiation will not usually overlap the same areas with important effects unless two or more bombs are detonated close to a single target. Local fall-out from surface bursts is about the only effect overlapping from one bomb to another, especially true in the downwind directions. A nuclear explosion is described, differences in air bursts and surface bursts are discussed, and the various nuclear weapons effects on man and inanimate objects are described. The effects of thermal radiation from a nuclear burst, and the effects of nuclear explosions on man are also discussed. The shelter afforded by various types of conventional structures is discussed.

217

[FALL-OUT DISTRIBUTION IN U.S. AFTER NUCLEAR ATTACK]. TESTIMONY OF CHARLES K. SHAFER. p.43—55 of "Biological and Environmental Effects of Nuclear War. Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, Eighty-Sixth Congress, First Session, June 22-26, 1959. Part I."

Estimates are presented of fall-out conditions expected following a postulated nuclear attack under assumed weather conditions. The radiation doses to people in the fall-out zones are estimated. It is shown that the intensity of the radiation decreases with time but the radiation dose accumulates with the passage of time due to the continued fall-out and build-up on the ground. At a cost of about $150 to $200 per dwelling a fall-out shelter can be built which will protect from fall-out radiation, but not from heavy blast damage. Protection from biological and chemical warfare agents are also discussed briefly. The blast and thermal effects of nuclear weapons on dwellings within the United States are tabulated and discussed.

218

[DOSIMETRY OF DIRECT RADIATION FROM NUCLEAR WEAPONS]. STATEMENT OF G. S. HURST. p.140—7 of "Biological and Environmental Effects of Nuclear War. Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the

United States, Eighty-Sixth Congress, First Session, June 22-26, 1959. Part I."

Applications of radiation dosimetry studies to the evaluation of environmental and biological consequences of nuclear war are discussed. Data are reviewed on the medical condition of individuals in Hiroshima and Nagasaki exposed to the effects of atomic explosions. Results are reported from a survey of the radiation doses for individuals located in houses in Hiroshima and Nagasaki and application of the results to problems of protection against prompt weapons radiation. Data are summarized from weapons effects studies and the shielding characteristics of various materials for prompt weapons radiation. Results are included from a Hartack Operation study of the mutual shielding in a cluster of light frame houses.

219

EVALUATION OF RESIDENTIAL STRUCTURES FOR SHIELDING AGAINST FALL-OUT RADIATION. J. A. Auxier. p.148—51 of "Biological and Environmental Effects of Nuclear War. Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, Eighty-Sixth Congress, First Session, June 22-26, 1959. Part I."

Results are reported from experiments for the evaluation of the shielding afforded by typical domestic houses against fall-out radiation. Experimental results are compared with theoretical studies.

220

SHIELDING FROM FALLOUT RADIATION. Charles M. Eisenhauer. p.151-63 of "Biological and Environmental Effects of Nuclear War. Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, Eighty-Sixth Congress, First Session, June 22-26, 1959. Part I."

Results are reported from calculations and experiments to determine how radiation dose rates are modified inside buildings. In one experiment the roof, walls, and floors of a building were treated as barriers which reduce the intensity of gamma radiation. Calculations were also made for water and concrete barriers and lead, iron, and concrete. Data are included from experiments on the radiation shielding afforded by various types of structures.

221

[FALL-OUT RADIOACTIVITY]. SUPPLEMENTAL MATERIAL. Ralph E. Lapp. p.210-28 of "Biological and Environmental Effects of Nuclear War. Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, Eighty-Sixth Congress, First Session, June 22-26, 1959. Part I."

Data on the radioactivity of fission products are discussed. An estimate is presented of intercontinental fall-out resulting from a high level attack of 10,000 megatons upon the United States. The radiation dose in the U.S.S.R. during the first year is also estimated. The behavior of fall-out debris is examined from the standpoint of the external radiation hazard presented by local deposition of bomb-produced radioactivity. The effectiveness of residences as fall-out shelters is discussed and problems of home defense are considered. The status of the Federal program of civil defense is reviewed. The potentialities of enemy missile warheads and our strategic retaliation capabilities are discussed. It is concluded that the random sprawl of our cities coupled with the inherent inaccuracy of ballistic missiles makes it probable that large areas of our metropolitan sections will remain outside zones of heavy blast damage. The greatest hazard to the population will be from radioactivity in fall-out which will reach a peak about 50 to 75 miles downwind from the blast. The fundamental rule for survival in time of fall-out or suspected fall-out is below-ground shelter. This evasive action must take priority over all other activities. The average basement provides a ten-fold to twenty-fold reduction in the radiation dose. A tunnel in the cellar wall, stacked bags of coal, sand, or containers of water in a corner of the basement would also reduce the radiation dose. Data are tabulated on radiation doses at various times following a nuclear attack. Possible decontamination measures are considered.

222

SURVIVAL MEASURES. Walmer E. Strope. p.678-96 of "Biological and Environmental Effects of Nuclear War. Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, Eighty-Sixth Congress, First Session, June 22-26, 1959. Part I."

Possibilities of defense against nuclear war are considered. Defense during the emergency phase and during the operational recovery phase of the attack are considered. Adequate shelter is considered the central countermeasure during the emergency phase of radiological defense. Design criteria for satisfactory shelters are presented. Within the basic specifications a number of alternatives are considered with respect to the degree of austerity in living accomodations and comfort in the shelter. Results indicate that adequate fall-out shelters may be provided for approximately $100 per person. Reclamation activities and costs are also discussed.

223

[EFFECTS OF THERMONUCLEAR WAR]. STATEMENT OF HERMAN KAHN. p.882-922 of "Biological and Environmental Effects of Nuclear War. Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, Eighty-Sixth Congress, First Session, June 22-26, 1959. Part I."

Based on an objective study of the possible effects of thermonuclear war, it is concluded that while thermonuclear war would be an unprecedented catastrophe the limits on the magnitude of the catastrophe may be sharply dependent on what prewar measures have been taken. The study suggests that for the next 10 or 15 years, and perhaps for much longer, feasible combinations of military and nonmilitary defense measures can do much toward preserving a resonable semblance of our prewar society. It was concluded that shelters with long occupancy time and the use of known anti-contamination techniques should make it possible to handle the acute radiation problem for the first three months following even severe attacks. In addition to protecting people from the immediate effects of the war, it is necessary to insure their survival in the postwar environment and to restore prewar standards of living if possible. This survival can best be accomplished if time-consuming preliminaries such as those involved in research, development, planning, analysis, design, programming, and legal questions have already been accomplished. A civil defense program is proposed and analyzed for cost. Combinations of military and nonmilitary measures which could provide valuable levels of protection in a nuclear war are discussed. The role of national policy and the attitude of the population is stressed.

224

[EMERGENCY PROTECTION MEASURES IN NUCLEAR

ATTACK]. STATEMENT OF DR. WILLARD F. LIBBY. p.923-41 of "Biological and Environmental Effects of Nuclear War. Hearings Before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, Eighty-Sixth Congress, First Session, June 22-26, 1959. Part I."

In the event of a nuclear war the number of casualties at the target may be relatively low in number but for hundreds of miles downwind the residual radiation will injure or kill those who are unprepared. Thus a densely populated area may find itself involved with results of events occurring hours earlier and many miles away. Our survival and recovery actions will depend upon an educated public who know about fall-out and the effects of nuclear radiation on people, animals, plants, food, and water. The policy of providing fall-out shelter is cited as an example of a practice which should be observed and copied. A design for a group shelter to protect 100 persons for two weeks or longer is presented. Various types of radio-radiation detectors, radiation detectors, and audible warning systems are described. Development is discussed of an inexpensive accessory for a transistor radio which will serve as a radiation warning device.

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